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RAF Harrier II

By Andy Evans

ZD470/60, a GR.9 of Joint Force Harrier, is seen over RAF Akrotiri in Cyprus carrying AGM-65 Maverick missiles, shortly before the type was retired. This aircraft was written off following multiple bird strikes in November 2010, while en route from Cotesmore to Cardiff Airport, and was one of a number of Harriers that were sold to the US Government for spares recovery for their AV-8 fleet. *(RAF)*

Harrier GR.5 ZD318, first production aircraft, Dunsfold Aerodrome, April 1985. The first two production GR.5s were originally finished in a scheme of Dark Sea Grey and Medium Sea Grey.

Harrier GR.5 ZD348, No. 233 Operational Conversion Unit, RAF Wittering, March 1989. This aircraft carries the standard NATO Green and Lichen Green scheme, typical of all GR.5 and early GR.7 Harriers.

Harrier GR.5 ZD379, No. 1 Squadron, RAF Wittering, seen at Chièvres Air Base, June 1989. Note the yellow border around the code number.

Harrier GR.5 ZD402, Rolls-Royce Pegasus 11-61 testbed, RAF Boscombe Down, June 1989. Fitted with the upgraded engine later used in the GR.7 and GR.9, this aircraft featured a distinctive 'Midnight Blue' finish with white trim.

Harrier GR.5 ZD407, No. 3 Squadron, RAF Gütersloh, July 1989.

Harrier GR.5 ZD400, No. 1 Squadron, RAF Wittering, deployed to Bardufoss for exercise Cold Winter March 1990. Like the GR.3s before them, squadrons applied a temporary Arctic scheme to their aircraft while on detachments to Norway.

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INTRODUCTION

Harrier II - A New Generation

Development of a much more powerful successor to the original and surprisingly successful Harrier I began in 1973 as a co-operative effort between McDonnell Douglas (MDD) in the US and Hawker Siddeley (in 1977, its aviation interests were nationalised to form part of British Aerospace) in the UK. Despite being slated as 'only able to carry a matchbox over a football field', the original Harrier had surprised many with its VSTOL abilities, allowing it to operate from austere sites close to the battlefield. Despite its size and unusual design, it still packed a punch – something that was not lost on the US Marine Corps.

Even as these first-generation Harriers, such as the GR.1/3 and AV-8A/C, were being introduced into RAF and USMC service, operational experience had already highlighted the need for an even more capable aircraft. Whilst acceptable for its time, the Harrier GR.3 and AV-8A/C were never going to fulfil the long-term needs of the RAF or indeed the US Marine Corps, with their ageing technology and modest weapons load.

Despite it being a British concept, for the next generation of Harrier, it was the US Marines who took the lead, based on the operational success of their AV-8A/C aircraft. What they needed now was a modern follow-on aircraft that met the Corps' future requirements for a 'light attack' aircraft that carried a big punch and continued the Corps' VSTOL doctrine.

Above: Harrier GR.7 with SNEB pods fitted CREDIT BAe Systems

Studies undertaken by McDonnell Douglas, following their aborted collaborative AV-16 effort with the UK, led to the AV-8B Advanced Harrier Programme, originally proposed in 1973 and formalised by the Defence Armed Services Committee in March 1976. Central to this new breed of Harrier was

Below: McDonnell Douglas modified two AV-8As with new wings, revised intakes, redesigned exhaust nozzles, and other aerodynamic changes. *(McDonnell Douglas)*

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Right: Designated YAV-8B, the first converted aircraft flew on 9 November 1978. *(McDonnell Douglas)*

an advanced 'big-wing', originally proposed by Hawker and then further defined using NASA-based technology of supercritical aerofoils, where drag was reduced and lift increased.

To achieve the maximum benefits in terms of weight saving, advanced structural materials were used instead of traditional metal, and the unique graphite epoxy construction gave the AV-8B the first carbon-fibre technology wing fitted to a military aircraft. At the rear of the wing, a large, single, slotted flap was integrated to support the jet efflux from the engine nozzles, which increased take-off lift and helped to arrest the loss of performance during vertical landings. The outrigger wheels were also moved inboard to better facilitate rough field work, and the 'elephant's ear' engine intakes were redesigned and increased in size – initially with a double row of suction relief doors, later revised to a single row – and the forward cold-air nozzles reshaped to a 'zero-scarf' design.

As the USMC wanted a substantially improved Harrier without the development of a new engine, the plan for the Advanced Harrier development was authorised by the United States Department of Defense in 1976. The US Navy, which had traditionally procured military aircraft for the Marine Corps, insisted that the new design be verified with flight testing.

Thus, McDonnell Douglas modified two AV-8As with new wings, revised intakes, redesigned exhaust nozzles, and other aerodynamic changes to the modified forward fuselage, although the cockpit and canopy found on all subsequent aircraft were not incorporated on these prototypes. Designated YAV-8B, the first converted aircraft flew on 9 November 1978. The second aircraft followed on 19 February 1979 but crashed that November due to an engine flameout.

Flight testing of these modified AV-8s continued into 1979, and the results showed greater than expected drag, hampering the aircraft's maximum speed. Further refinements to the aerodynamic profile yielded little improvement, although positive test results in other areas – including payload, range, and V/STOL performance – led to the award of a development contract in 1979. The contract stipulated a procurement of twelve aircraft initially, followed by a further 324. In August 1981, the programme received a boost when British Aerospace (BAe) and McDonnell Douglas signed a memorandum of understanding, marking the UK's re-entry into the programme, with the UK government being enticed by the lower cost of acquiring Harriers promised by a large production run, and the fact that the US would be shouldering the expense of development.

Below: GR.5 DB1 ZD318 on a test flight, showing its various component materials. *(BAe Systems)*

Harrier GR.5

At the time, the UK government had only a minor requirement for up to sixty Harriers, and competing pressures on the defence budget left little room for expenditure such as an 'Advanced Harrier'. A lack of government backing for developing the necessary engine for the new aircraft, the Pegasus 15, led Hawker to withdraw from the project in 1975. Due to US interest, however, work proceeded on the development of a less ambitious successor – a Harrier fitted with a larger wing and making use of composite materials in its construction. The US government was content to continue if a major foreign buyer was found, and the UK had a plan to improve the Harrier with a new, larger metal wing.

In 1980, the UK considered whether the American programme would meet its requirements. However, the opinion was that it required modification. Thus, the McDonnell Douglas wing design was altered to incorporate British-designed leading-edge root extensions, and in 1982 the UK opted to become fully involved in the joint US - UK programme. The agreement included the involvement of British Aerospace (BAe) as a major subcontractor, manufacturing sections such as the rear fuselage for all AV-8B customers. The Harrier II was therefore to be an Anglicised version of the AV-8B, with British Aerospace producing the aircraft as the prime contractor and McDonnell Douglas serving as a subcontractor, with final assembly work performed at Dunsfold.

The first prototype flew in 1981. The first BAe-built development GR.5 flew on 30 April 1985 and had many differences from the USMC AV-8B Harriers, such as avionics fit, armaments and equipment. The wing of the GR.5 featured a stainless-steel leading edge, giving it different flex characteristics from the AV-8B.

Part of the original Phase I of the 1976 Advanced Harrier Programme was the production of two Harrier Technology Demonstrators, as well as a full-scale wind tunnel test using the old AV-8A 158385. This was successfully completed in late 1976. The primary element of Phase II was to test the theories behind the AV-8B in flight, and to accommodate this, a pair of AV-8As were remanufactured as YAV-8B test aircraft. YAV-8B No.1, 158394, was completed on 1 September 1978, with its first flight on 9 November. The second, YAV-8B 158395,

Right: GR.5's 'big wing' can be seen here, with additional wing pylons afforded by the greater space – not originally fitted to the AV-8B. Also of note is the IFR probe. ***(BAe Systems)***

Below right: An RAF Germany-based GR.5 kicks up spray during a dispersed site exercise. ***(RAF)***

flew on 19 February 1979.

Modifications to the aircraft incorporated the new supercritical wing, improved inlet system and positive circulation flaps. The engine was the Pegasus II F402-RR-404 with 21,700 lb of thrust, which included a new gearbox, zero-scarf forward nozzles, and the same 'Lift Improvement Devices' such as the retractable underfuselage dam found on the AV-8C. The main fuselage of the aircraft remained largely unchanged from the standard AV-8A and included the under-fuselage ADEN (Armament Development Enfield) gun packs with strakes.

US Congress ordered four Full Scale Development (FSD) aircraft under the new designation AV-8B Harrier II. The AV-8B was a totally changed aircraft compared with the YAV-8. McDonnell Douglas produced the first batches of aircraft in St. Louis, before a work-share agreement with British Aerospace – now a partner, as the UK government had also ordered a derivative of the aircraft for the RAF – came online. BAe were responsible for the centre and rear fuselage sections, the fin and rudder, the centreline pylon and the reaction control system, and Rolls-Royce had the very important role of supplying the Pegasus engine.

The wing was by now well refined, with a LERX (leading-edge root extension) added to the roots and a completely new tailplane fitted, again using carbon fibre technology. The forward fuselage also incorporated a large area of carbon fibre components and featured a redesigned and raised 'bubble' canopy with a wraparound windshield, lifting the crew position, thereby giving a much better view and providing room below for some of the new avionics.

The avionics themselves were mostly brand new, although some were unashamedly borrowed from other McDonnell Douglas programmes. In the nose was a Hughes ARBS (Angle-Rate Bombing System), originally developed for the A-4M Skyhawk, with a TV and dual-mode tracker facility, projecting its information onto a Smiths Industries-upgraded SU-128/A HUD or onto the MFD (multi-function display) in the cockpit on the pilot's left. This could show sensor information, nav/mission plots, ARN-118 TACAN data, engine performance, and the SAAHS (stability augmentation and attitude-hold system). Such systems assist the accurate delivery of laser-guided as well as 'dumb' bombs.

Some cockpit interfaces were borrowed from the F/A-18, such as the improved HOTAS (hands-on-throttle-and-stick) controls, the AYK-14 mission computer, the ASN-130 INS, the Lear Siegler AN/AYQ-13 stores management system, and ECM-resistant fibre optic cables. The RWR and underfuselage AN/ALE-39 chaff and flare dispensers were the same as those used in the CILOP AV-8C programme. All aircraft information was fed through a 1553A databus, and in front of the pilot beneath the HUD was the UFC (up-front controller), his link with the computer system.

As noted earlier, in RAF service this new aircraft was essentially an 'anglicised' AV-8B with British avionics and given the designation 'Harrier GR.5'. The aircraft represented a major technological leap for the UK's Harrier Force – with further promise of even greater things to come as the aircraft matured. In 1981, the MoD confirmed an order for sixty Harrier GR.5s, with a further two examples to be acquired for pure development work. The GR.5 was purchased through a programme that continued the partnership between British Aerospace and

Left: The Harrier was a popular airshow performer. ***(Author)***

McDonnell Douglas. For the GR.5, however, the balance moved in favour of the UK, with an equal work-share in the GR.5, rather than the 60/40 share in the AV-8B. In August 1981, an MoU was signed in which the RAF agreed to buy the developed version of the AV-8B.

The original Harrier had already proved that it was a small target to spot. The exhaust nozzles, hidden under the high wings, left little heat signature, and the Pegasus put out little smoke. It also had remarkable reliability and turn-round time. A lot was expected of the new breed. Externally differing from the AV-8B only in the extreme nose section, the GR.5's main changes were internal. In the more spacious cockpit, the US AV-8B's Stencel ejector seat was replaced by a 'zero-zero' Martin-Baker Mk 12. The cockpit layout was definitely of the next century when compared with that of the GR.3. A Ferranti FIN.1075 INAS replaced the Litton AN/ASN-130 of the AV-8B (although early models carried the Litton system due to delays with the Ferranti model), providing a moving-map display on the starboard side of the fascia, fed by cassette tape of the pilot's intended sortie area. An MFD occupied the port side of the instrument panel. On the pilot's eyeline was a Smiths Industries HUD, below which was the pilot's UFC (up-front controller) – his interface with the aircraft's computer system. Traditional 'dials' are conspicuous by their absence, except for the basic flight instrumentation such as altitude, speed, AOA and a clock.

Above: A GR.5 wearing the 'Welsh Wildcat' emblem of the Harrier OCU. ***(Author)***

The side consoles carried fuel switches and lighting, oxygen and power supply switches on to starboard, with the HOTAS nozzle lever and throttle lever to port, along with other devices such as the SAAHS – essential for automatic stabilisation throughout flight – which also acted as an autopilot during take-off and landing. On the nose end of the GR.5 was the 'eye' for the Hughes AN/ASB-19 ARBS, which also contained a Dual Mode Tracker (DMT). In its TV mode, it projected target information and accurate angle-rate data to the pilot via his HUD or MFD, ensuring the best delivery for a single-pass attack. In its 'laser' mode, it could detect and lock on to targets being 'illuminated' by a ground-based or airborne FAC.

Like the AV-8B, the GR.5's use of composite materials was also an innovation, and the new 'big-wing' allowed for much-improved performance and increased the amount of weaponry that could be carried, with small LERX extensions (a British development originally destined for the GR.5(K)) at the wing roots. Under the wings themselves, instead of the five stations of earlier Harriers, the GR.5 had eight, with a pair of Sidewinder launch rails cleverly added to the front portion of the outrigger wheel fairings, thus not taking up valuable space needed for other weapons. In place of the AV-8B's GAU-12/U Gatling gun, the MoD

Above left: The GR.5's smaller LERX can be seen here. ***(Author)***

Left: A GR.5 from No.1(F) Squadron with Phimat pod on the wing pylon. ***(Author)***

Right: Arctic Warrior! A superb shot of a GR.5 in its temporary cold weather scheme. ***(BAe Systems)***

Below right: Another variation of the GR.5's 'arctic' camouflage. ***(Author)***

selected twin Royal Ordnance 25mm ADEN gas-operated revolver cannons with NATO Stanag 4173 ammunition, which, despite much work and effort, would never be accepted into service. Beneath the ARBS was a curiously shaped fairing for the proposed Miniature Infra-Red Linescan or MIRLS system, which was to have provided an all-weather reconnaissance capability. However, costs and delays forced the project to be shelved, thereby effectively 'losing' the reconnaissance capabilities of the GR.5, which were not fully re-addressed until the advent of the GR.7. The IFF transponder was also changed from the Bendix type fitted to the AV-8B to a Cossor IFF4760, and the RAF's radio suite was provided by GEC.

The engine chosen for the GR.5 was the Pegasus Mk.105, offering 21,750lb of thrust – some 300lb more than the engine of the AV-8B. This also contained the DECS (digital engine control system), which monitored the performance of the powerplant and managed the propulsion systems. Developed jointly by Rolls-Royce, British Aerospace, McDonnell Douglas and Dowty/Smiths Industries, this automatically adjusted the engine's thrust settings after taking into account speed, altitude, jet pipe temperature and acceleration – functions that previously had to be monitored by the pilot. A lengthy flight-testing programme was undertaken with the initial development aircraft ZD318 (DB1), which first flew on 30 April 1985, with ZD319 (DB2) testing the engine, systems and ordnance trials. However, lengthy delays with the avionics fit and weapons clearances resulted in the first GR.5 not being delivered until May 1989. ZD318 was rolled out and flown with strakes, not gun packs, in an unpainted state. The only concession to any type of commemorative marking was a large white 'Harrier' and a large red 'GR.5' on the nose, and 'ZD318' roughly stencilled on the tail fin.

Below: Resplendent in its overall blue scheme is ZD402 with the Pegasus II-61 engine fitted. ***(Rolls-Royce)***

The RAF's order for sixty production aircraft was split into forty-one to be completed as standard GR.5s and the remainder as GR.5As. The RAF's procurement of sixty aircraft was for forty-one of GR.5 standard, serialled ZD320–330, ZD345–355, ZD375–390 and ZD400–412. The remaining aircraft, serialled ZD440–439 and ZD461–470, were built to GR.5A standard, incorporating wiring and other changes to allow the aircraft to be retrofitted to GR.7 standard at a later date. A plastic replica, ZD472, was also created for recruiting purposes.

A major factor in the service delay was the sad and somewhat bizarre loss of GR.5 ZD325 on its last pre-delivery trip on 22 October 1987, with Taylor Scott at the

Right: Phimat pod fitted to the outer wing pylon. *(Author)*

controls. While checks were being made over Salisbury Plain, contact was lost with the pilot, although the aircraft continued to be tracked heading west. It was eventually sighted by a USAFE F-15, which reported that the canopy was shattered but the ejector seat – minus its pilot – was still in position. The aircraft flew on for another hour and a half before plunging into the sea. Scott's body was recovered from a small town in Wiltshire, and investigations concluded that his ejector seat manual separation system had accidentally fired, dragging him out of the cockpit.

Following these unfortunate delays, RAF Wittering – the 'Home of the Harrier' – finally received its first GR.5, ZD323/A, on 30 April 1987. This aircraft was intended for familiarisation only and was immediately taken on charge by the GR.5 Conversion Unit – GR5CT – formed within No.233 OCU, flying its first sortie on 30 March 1988 with Sqn Ldr John Baynton at the controls. In all, eight aircraft were received by the GR5CT, and their personnel were all trained by the US Marine Corps at Cherry Point, using their simulator and by flying the already in-service AV-8B. On 28 September 1988, Wing Cdr Peter Day, AFC, the then OC of 233 OCU, climbed out of a Harrier GR.5 and into the record books as the first pilot in the world to complete 3,000 hours on the Harrier, with a special marking applied to the nose: 'Wg Cdr Pete Day 70–88 3,000hrs'.

The original plan was to equip the two RAF Germany squadrons with the GR.5 first, but this was thwarted by many factors. The first unit to form up, on 23 November 1988, was fittingly No.1(F) Squadron, which had been instrumental in bringing the Harrier GR.1 into service. They finally relinquished their trusty GR.3s in early spring 1989 and were fully operational with the GR.5 by 2 November 1989, after being declared to SACEUR's Strategic Reserve (AIR) on 2 October. No.1(F) Squadron also made the first live firing of a Sidewinder missile by an aircraft on operational duty when Flt Lt 'Spike' Jepson released an AIM-9L at a flare towed behind a low-flying Jindivik drone over the Aberporth range in June 1989. Conversion by 233 OCU mirrored that of No.1(F) Squadron, the former also being operational by April 1989, from which time deliveries switched to No.3 Squadron at Gütersloh, where the first GR.5 arrived in December 1988, reaching operational status in April 1990.

The GR.5 also introduced a new approach to camouflage, as the usual RAF disruptive style of paintwork was replaced by an overall block colour scheme. In the case of the GR.5, this consisted of NATO Green on the upper fuselage and Lichen Green on the undersides. With the introduction of the GR.5, it was once again necessary to deploy these assets to the frozen north – not only to continue development of the aircraft as a weapons system, but also as part of the annual reinforcement exercises, to provide a strong, visible deterrent and demonstrate the GR.5's ability to match and exceed the older GR.3 in all theatres of conflict.

It was in November 1989 that No.1(F) Squadron first took four of its new GR.5s to Norway for a brief work-up at their Bardufoss base near Tromsø, 150 miles inside the Arctic Circle. Four months later, on 8 March 1990, they returned to take part in the NATO exercise 'Cold Winter', this time deploying a total of eight Harrier GR.5s. Six of the GR.5s were painted in a new variation of the winter camouflage scheme, while the other two and an older two-seat T.6 retained their standard schemes.

On winter-scheme GR.5s, this involved applying a white ARTF over-wash to form a 'mottled effect' on the top, sides and under-nose surfaces, with at least one aircraft having the pattern applied to the underside of its wings. Most of the six had the white paint applied with a 'hard' edge, although one aircraft was noted to have some areas sprayed with soft edges. The scheme was intended to break up the outline of the aircraft and make it more difficult to detect. However, no matter how attractive it made the aircraft appear, the scheme was less successful than when applied to the GR.3. Although it blended well against the multi-coloured, snowy landscape, the aircraft were easy to spot when moving over plain, dark terrain or heading out across the sea. The scheme was therefore short-lived, and subsequent deployments have featured aircraft in their standard camouflage.

In preparation for the arrival of the next Harrier variant, the GR.7, in summer 1989, a trio of GR.5As from the Strike Attack OEU deployed to the US Weapons Center at China Lake to carry out an evaluation of the Marconi Zeus ECM system and the tailcone-mounted, semi-active Plessey MAWS, which was designed to warn of the launch of heat-seeking missiles, such as the Russian SA-7 Grail. It was decided that No.3 Squadron's co-located sister unit, No.IV(AC) Squadron, should not receive the GR.5 but instead go straight to the upgraded GR.7, and thus took on charge ZD473 in late December 1990. Another user of the GR.5 was the Boscombe Down-based Strike Attack OEU, which had three GR.5s on strength during the early 1990s.

Left: The GR.5 was slated to have a Miniature Infra-Red Linescan System (MIRLS) in the nose, but the project was shelved. *(Author)*

Above: BAe Systems development jet ZD318 was reworked to GR.7 standard for trials. ***(Author)***

Left: A close-up view of the modified FLIR fairing fitted to the 'Nightbird' Harrier. ***(Author)***

Harrier GR.7

As the GR.5 was a quantum leap in technology over the GR.3, so the GR.7 registered great strides over the GR.5. Even though externally the GR.7 was essentially a GR.5 with a different nose, in terms of capabilities the GR.7 was exceptional. It gave the RAF the ability to operate its Harrier Force by day or night and in all but the foulest weather. However, as the RAF was always at pains to point out, the GR.7 could not claim the title 'all-weather'.

The 'night' capability was afforded by the addition of a GEC FLIR fitted on the upper surface of an elongated nose section, which also housed the external antennas for the forward hemisphere Marconi Zeus ECM system, located on its underside below the 'eye' of the ARBS system. The second element in the night suite was the addition of GEC Nightbird Night Vision Goggles – NVGs – and these two systems combined almost doubled the hours available to the Harrier Force for combat duties.

The FLIR was an off-the-shelf GEC unit, mounted ahead of the windshield in direct line with the pilot's vision, and its image could be overlaid onto a Smiths Industries wide-angle HUD, which also displayed the usual flight information. The FLIR showed small 'V' markers representing its sensing of 'hot spots' such as vehicle engines. However, it was limited by thick cloud due to the effects of water vapour on its image. Below the new HUD, on either side of the main panel and UFC, were two Multi-Purpose Colour Displays (MPCDs), which presented colour moving-map data on the left and FLIR imagery on the right. Controlled from the HOTAS throttle quadrant were the means to alter the FLIR's polarity, according to what the pilot felt best suited his mission. The Nightbird goggles were an excellent complement to the FLIR and invaluable when

Left: ZG472 of the Strike Attack OEU. ***(Author)***

Right: A GR.7 from No.1(F) Squadron sits on the Bodø runway during a 'Cold Winter' exercise. *(RAF)*

Below right: Temporary hides were a big part of the Harrier's dispersed operations doctrine. *(Author)*

the pilot was searching for a target or 'looking into a turn' ahead of the FLIR's view. Cockpit lighting was suitably reduced to accommodate the goggles' performance.

Carried over from the GR.5 was the Hughes AN/ASB-19(V) ARBS, which, although lacking night-time capabilities, remained extremely useful in daylight hours, with its x6 magnification TV picture, which could be displayed on either MPCD. The HOTAS controls were also enlarged to aid operation of the new systems. The tailcone of the Harrier was designed to accommodate the Plessey radar-jamming semi-active MAWS. The ejection system remained the standard Martin-Baker Mk 12 zero-zero unit.

The GR.7 fleet was also fitted with GPS in a fleet-wide modification programme, used in conjunction with the GEC Ferranti FIN 1075G (for GPS-fitted) INS and colour moving-map display, giving the aircraft highly precise navigational ability to within 30m of the intended 'target'. It also aided operations from dispersed sites in less-than-ideal weather conditions. The GPS aerial was identified as a small, white, circular fairing flush-mounted to the spine. The GEC Marconi ARI 23333 Zeus threat identification and jamming system utilised a programmable library of known radar threats (quickly updateable). Once a threat was detected, it activated jamming procedures and deployed chaff and flares accordingly, capable of identifying 1,000 different types of emitters. Threat data was displayed to the pilot on his HUD or MPCDs, as well as by the traditional 'howl' in his headset.

The turning performance of the GR.7 was further enhanced by the fitting of the 100% LERX – a fit that was to become standard on all Harriers, rather than the smaller version originally installed on the GR.5. However, this fit initially fell foul of financial constraints. The full-sized LERX was introduced in 1991 on ZG506, following modifications to the Honeywell AN/ASW-46(V)2 SAAHS. At the same time, new engine fire access panels were added, shaped like small air scoops above the LERX, as the 100% LERX type covered the original access 'holes'.

The GR.7 could carry the same weaponry as the GR.5, including SNEB and CRV-7 rocket pods, standard iron bombs, LGBs and CBUs, and a pair of Sidewinder AAMs could also be routinely carried. Even with the advent of the GR.7, the Royal Ordnance 25mm pneumatically-cocked ADEN revolver cannons were still not cleared for service, and the aircraft continued to carry the old but empty 30mm packs to aid VSTOL performance. The Sidewinder launch rails

Below: A No.3 Squadron GR.7 with its colourful tail. *(Author)*

Right: Here you can see the antennae for the Zeus ECM system under the nose. ***(Author)***

were refitted with the Swedish-made BOL system, which cut and fired chaff from a rear dispenser – the rounded front end containing a propellant gas bottle. In some instances, a Philips Matra Phimat pod was carried on one of the outer wing pylons, before the BOL became the standard pylon fit.

The last thirty-four of the ninety-six single-seat Harriers built for the RAF were delivered as GR.7s, and the remainder were converted by BAe from existing GR.5s or GR.5As. The GR.5A designation was an interim measure, essentially a GR.5 with an empty GR.7 nose, complete with wiring for the new systems. These interim airframes almost all went into store at RAF Shawbury, except for ZD433, which went to RAF Wittering as a maintenance trainer; ZD466 went to Rolls-Royce at Filton, and ZD470 to the A&AEE.

The first Dunsfold-reworked GR.5, ZD380, was delivered to service on 21 December 1990, joining No.IV(AC) Squadron at Gütersloh. The first GR.5A fitted as a full GR.7 arrived for upgrade in September 1990 and joined No.IV(AC) Squadron in April 1991. The first new-build GR.7, ZG471, entered service with No.1(F) Squadron, and ZG472 was the first to arrive at the SAOEU in May 1990.

In 1989, ZD318 (DB1), one of the two original Harrier development aircraft, was

Right: ZG478 with anniversary tail markings and toting rocket pods. ***(RAF)***

Below: A GR.7A armed with Enhanced Paveway II Laser Guided Bombs prepares to launch during Exercise 'Magic Carpet'. ***(RAF)***

Right: A No.20 Squadron GR.7 coming in for a closer look. ***(RAF)***

Below right: Empty 25mm gun packs were still carried to aid VSTOL performance. ***(RAF)***

outfitted with the night systems and new nose section and moved to the A&AEE to continue work on the new equipment. ZD319 (DB2) was fitted out as a GR.5A. Both retained their original development medium sea grey and dark sea grey colours; ZD318 gained black and white photo-reference markings and was used for airframe assessments, including ski-jump trials.

In order to bring the Night Attack Harrier into service with the front-line squadrons, it had originally been intended to establish a specialist flight of six aircraft attached to No.1(F) Squadron at RAF Wittering to act as a training organisation. In the event, it was decided that the whole Squadron should be night-capable, thereby making it the RAF's first fully operational Night Attack Harrier unit, without standing it down from its NATO commitments.

In June 1992, No.1(F)'s Harrier GR.5s began to be exchanged for a modified batch of GR.5As, now with full mission fit as GR.7s, the first two being ZD461 and ZD434. The first GR.7 night sortie was made on 2 June 1992 in ZD434, and on the 19th, Flt Lt Lance Nichol in ZD437 made the first trip using the FIN 1075G, with which six other aircraft (ZD431/435/437/438/463/464) had also been equipped as a special trial fit.

It was not envisaged that other units should use the night systems until the mid-1990s, but it was prudent to continue converting them to the new type. Therefore, No.IV(AC) Squadron, then based at Gütersloh – the only unit not equipped with the GR.5 and the last to fly the GR.3 operationally – began converting straight to the GR.7 on 12 September 1990 with the arrival of ZG473. No.3 Squadron, also located at Gütersloh, traded up its GR.5s for GR.7s on 30 November 1990, receiving its first aircraft, ZG479.

As a result of the ending of the Cold War and the adoption of the 'Options for Change' programme, both No.3 and No.IV(AC) moved from Gütersloh to Laarbruch during the latter part of 1992. It was also intended that the complete removal of Harriers from Germany should be accomplished by 1999, when the two units would return to RAF Cottesmore, thus forming a 'twin-base' arrangement with nearby Wittering.

The Harrier OCU, which by this time had assumed the title of No.20(R) Squadron, began receiving both reworked and new-build aircraft from January 1993. ZG473, the first new GR.7, was destroyed in May 1991, and ZG430, the first conversion, was lost in June 1993. An electrical failure aboard ZG473, followed by a similar occurrence aboard ZD353, led to the temporary grounding of the Harrier fleet. It was discovered that chafing wires were responsible for the problems, and BAe swiftly rectified the matter. The last GR.7, ZG862, was delivered to Gütersloh on 2 June 1992.

Much of the work undertaken in bringing

Left: A No.IV(AC) Squadron Harrier demonstrating what the Harrier did best – operating from rough or austere sites. ***(RAF)***

Right: ZG330/11 rolls out showing a pair of AGM-65 Mavericks on the wing pylons. *(RAF)*

the Harrier GR.7 into service was assigned to the Strike Attack Operational Evaluation Unit (SAOEU), based at Boscombe Down in Wiltshire. Early work in developing the Harrier's night-attack systems was undertaken using two Harrier T.4s, XW267/SA and XW269/BD, of which XW269 was modified to a derivation called the 'Nightbird Harrier' (complete with a 'blindfolded crow' nose artwork). Along with a Buccaneer S.2 from the *A&AEE*, a Tornado GR.1 and a FLIR-podded Jaguar T2A, it undertook the lion's share of the trials work.

Although based at Boscombe Down, much of the 'Nightbird' Harrier flying took place at RAF Lyneham in Wiltshire. However, it was another Harrier that pioneered the earliest FLIR trials in 1983, when RAE Bedford's flying test bed XW175 was used to extend the then RAE Farnborough 'Nightbird' programme into the VSTOL regime. XW175 was fitted with a pod-mounted FLIR under its port wing, and night vision goggles were worn by the crew. This brief trial concluded in December 1983.

The 'Nightbird' Harrier was fitted with an experimental FLIR system, housed in the nose section originally modified to carry the LRMTS in the Harrier GR.3 and T.4, and was further fitted out with a version of the Ferranti 4510 cursive/raster HUD and an FD.500 video camera. Trials began by the SAOEU in 1990 alongside the GR.7 programme, the unit then having three GR.7s assigned to it for evaluation.

Right: BAe Systems GR.9 trials Harrier with captive Brimstone anti-armour missiles fitted. *(BAe Systems)*

Below: Harrier GR.7s from No.3(AC) Squadron aboard HMS *Illustrious* during Exercise 'Saif Sareea'. *(RAF)*

Above: Strike Attack OEU Harrier GR.7 pulls into a turn along the coastline. *(RAF)*

Left: Ordnance ready to be loaded aboard GR.7s operating from HMS *Illustrious*. *(Royal Navy)*

Work also commenced to add NVG-compatible lighting to the Harrier, with experimental operations again undertaken using the Nightbird T.4, which flew the initial NVG sortie on 11 December 1990. A new lightweight GEC Nightbird goggle set, on a swivel mounting attached to the pilot's helmet giving a 40-degree field of view, was tested. Because of the 'g' forces that would be exerted if the pilot ejected while still wearing his NVG, a broken neck seemed almost a certainty.

The Nightbird goggles system, however, was unique in having a miniature detonation system fitted to the helmet clip; this in turn was attached to the ejection seat firing mechanism by a 'pigtail' lead from the back of the pilot's flying helmet. In the case of an ejection, a fraction of a second before the seat fired, an electrical pulse was generated to blow away the goggles, thus saving the pilot from further injury. To facilitate this system, the standard Martin-Baker ejector seats were replaced by the Mk 12-2, which incorporated the new circuitry for NVG wearers. The pilot therefore wore, as standard for night profiles, a Mk 4 helmet fitted with a clear plastic visor clipped to the front to form a protective barrier between his face and the NVG. For ordinary missions, they continued to wear the multi-layered Mk 10.

With the GR.7 soon to be introduced to squadron service, the SAOEU's work continued apace, and during March 1991 a detachment of three GR.7s was sent to MCAS Yuma to work alongside the US Marines' AV-8Bs in nocturnal operations. Procedures were developed for night landings using electroluminescent stripes to mark landing zones, and other important tactics were refined, such as the use of a Tornado GR.1 with its powerful radar to guide a flight of Harriers through bad weather.

Trials were undertaken to bring all of the weaponry and defensive systems used by the GR.7 into service, including the use of

Left: A Harrier GR.7 is moved onto the flight deck elevator of HMS *Illustrious* in the Persian Gulf. *(Royal Navy)*

Right: ZG504/75A, a GR.7A from No.800 Squadron. *(Royal Navy)*

TIALD with laser-guided munitions. The SAOEU also pioneered the GR.7's introduction to carrier operations when three examples were deployed to RNAS Yeovilton for ski-jump training on 20 June 1994. Flt Lt Chris Norton, flying ZG475, had the honour of becoming the first RAF pilot to land a second-generation Harrier on a ship when, on 27 June, he alighted on HMS *Illustrious*. Sadly, on 1 June 1995, Harrier GR.7 ZG475 flew into the sea off Wigtown Bay while on an equipment evaluation trial from Boscombe Down, and its pilot was killed.

The RAF saw further advantages available from the GR.7 and pressed forward with a much-improved version – the GR.9 – and, as an interim upgrade, introduced the 'GR.7A', the first stage in the transition to Harrier GR.9 standard. The GR.7A was essentially a GR.7 fitted with an uprated Rolls-Royce Pegasus 107 engine, and when these aircraft were upgraded to GR.9 standard, the uprated engine variants retained the A designation, becoming GR.9As.

Some forty GR.7s were slated to receive this upgrade, and all GR.7 aircraft were to be made capable of using the Mk.107 engine when converted to GR.9 standard. The Mk 107 engine provided around 3,000lb of additional thrust compared to the Mk.105, improving aircraft performance during 'hot and high' conditions and carrier-borne operations.

Other non-flying changes arrived in the realm of basing for the Harriers. Since the type had entered service, the traditional 'Home of the Harrier' had been RAF

Right: A pilot clips on his Night Vision Goggles. *(Author)*

Below: ZD378/26 of No.20(R) Squadron in special markings. *(Author)*

Right: A Harrier GR.7 in winter camouflage. *(Author)*

Wittering. However, with the cessation of Tri-National Tornado Training at nearby RAF Cottesmore and the arrival of the 'Joint Force Harrier' concept – together with the 'Naval Strike Wing' – the Harriers took up residence at Cottesmore, thereby establishing a dual-basing arrangement. The Harrier OCU then occupied the Wittering site for training purposes, whilst all operational units flew from RAF Cottesmore.

Harrier GR.9

The Harrier GR.9 was a heavily updated development of the GR.7, incorporating the ability to use a wide range of advanced precision weaponry, new communications systems and airframe upgrades. The programme had two main features: the Harrier Integrated Weapons Programme (IWP), devised to bring together a number of discrete weapon-system enhancement projects, and the introduction of the Pegasus Mk 107 engine.

The GR.9 carried a new digital weapon system, an advanced Global Positioning System and the ability to drop six Paveway IV bombs, which were linked by a new onboard computer, plus both infrared and television variants of the AGM-65 Maverick missile. However, plans to outfit the Harrier with Storm Shadow, Brimstone and ASRAAM were shelved.

Although the introduction of smart weapons was the backbone of the IWP, the Harrier GR.7 required various system upgrades before it could operate them

Right: White ARTF was roughly applied as a winter coat for deployments to Norway. *(Author)*

Below: A Harrier GR.9 aircraft conducts a combat patrol over Afghanistan on 12 December 2008. *(RAF)*

Above: An informative plan view of the Harrier GR.9. ***(RAF)***

Left: Steam and spray fly up from the wet runway as this No.1(F) Squadron GR.9 lands. ***(RAF)***

effectively. An all-new state-of-the-art MIL-STD-1760 Stores Management System (SMS) was fitted, combined with a High Order Language (Ada) Operational Flight Programme (OFP) and a new Open System Mission Computer (OSMC), which permitted the aircraft to interact with the weapons. The use of smart weapons also necessitated the introduction of a new Inertial Navigation System/GPS (INGPS), capable of providing the weapons with navigation data via the 1760 SMS. Improvements to the aircraft display system were also added to cope with the additional symbology requirements.

The integration of these new weapons allowed the Harrier to hit a wider range of targets at longer range with less risk to aircrew. The 'Successor Identification Friend or Foe' system was fitted to reduce vulnerability on operations, and a ground proximity warning system was added. For training, the 'Rangeless Airborne Instrumentation and Debriefing System' (RAIDS) was also carried.

The programme also included an upgrade to the two-seater T.10 training aircraft to T.12, the equivalent of the GR.9 standard. Additionally, a structural modification programme, known as HMP (Harrier Modification Programme) 3, was undertaken to address the composite rear fuselage and to cope with fatigue cracking caused by the Pegasus engine's exhaust. This update programme was managed through the Future

Left: GR.9 ZG502/73 from No.20(R) Squadron taxies out. ***(RAF)***

Integrated Support Team (FIST), and the first aircraft flew in May 2003, with an initial batch completed by the end of that year. All GR.7s receiving the IWP were re-designated GR.9, and of these, thirty were further upgraded with the Pegasus Mk 107 engine to become GR.9As. Twenty aircraft initially fitted with the Mk 107 engine were known as GR.7As whilst awaiting the IWP modifications.

Due to the Harrier's experiences in Afghanistan as part of 'Operation Herrick' and the second Gulf War under Operation 'Telic', new items of kit were brought into the inventory under the UOR (Urgent Operational Requirements) system, allowing much-needed hardware to be rapidly introduced into service.

Above: A GR.9 from No.800 Squadron leaves HMS *Ark Royal* for the last time. *(Royal Navy)*

With the upturn of activity in Afghanistan during 2006, it was found that the TIALD pod was not ideal for the type of warfare being undertaken, and a UOR was issued for an improved system. The RAF evaluated the Rafael Litening III and Lockheed Martin Sniper systems, choosing the latter due to a faster integration cycle.

Another UOR saw BAe Systems produce the Terma Advanced Countermeasures Dispensing System (ACDMS), which was, within a very limited timeframe, developed and tested for the Harrier GR.9 and deployed on aircraft operating in critical areas of Afghanistan. The Terma configuration included a new pod structure fitted with the Terma ACMDS and BAe AN/AAR-57 Missile Warning System, which had five Missile Warning Sensors, combined with an Electronic Warfare Management Unit (EWMU) and Tactical Data Unit (TDU), all integrated into the cockpit.

Also employed was the Digital Joint Reconnaissance Pod (DJRP), mounted on the aircraft's centre-line pylon. It contained various electronically-scanned sensors, a number of electro-optical camera options and an Infra-Red Line Scanner (IRLS). All sensors recorded to analogue SVHS tapes, providing high-resolution still or moving images of the target area to a software-based Ground Imagery Exploitation System.

The various EO camera options fitted to the DJRP enabled it to operate either at medium or low level. For medium-level operation, one camera was mounted in the nose of the pod and could be rotated through

Above left: A head-on view of a Harrier GR.9 as it taxies out. *(RAF)*

Left: Harrier GR.9 ZG501/EB-Q of No.41 Squadron. *(RAF)*

Right: TERMA pod fitted to a GR.9. ***(RAF)***

180 degrees, from horizon to horizon. In the low-level mode, two fixed-depression EO cameras were mounted on either side of the pod, giving left-hand and right-hand coverage of the aircraft's track. The IRLS, common to all camera fits, was mounted in the rear of the pod, providing a slightly forward-looking, near-vertical, horizon-to-horizon coverage.

The GR.9 was further upgraded for its war role in Afghanistan as the Harrier GR.9A Cap C+, with a new aiming system for Paveway III and integration of Paveway IV, along with RAIDS, Successor IFF, the advanced Sniper Mk.2+, Terma EW and the Helmet Mounted Cueing System (HMCS). The HMCS allowed the pilot to quickly identify coordinates on the ground using a red 'diamond' projected on a reticule placed over his right eye. This was an excellent tool for increasing spatial awareness and eliminated the need to spend vital minutes using binoculars to identify features from a map.

Equally, in reverse, the pilot was able to look around the battlespace and, if he saw something of interest, simply look at it, designate it using controls on the throttle, and the Sniper pod would immediately move to that same point on the ground. At night, the pilot's NVGs were fully integrated with all systems, meaning night operations were exactly the same as during the day, including flying at low level. The cockpit displays could show anything from Sniper imagery to weapon programming, engine performance data or a moving map.

Left: Harrier T.10 ZH663 going vertical. ***(RAF)***

Below: T.10 ZH662 with SNEB pods. ***(Author)***

Bottom: T.10 is prepared for its next sortie. ***(Author)***

Harrier T.10 and T.12

Very much like the US Marine Corps, the RAF did not initially appreciate the need for a dedicated two-seat trainer for its Harrier pilots. The RAF's early thinking was to convert some of its existing T.4s and T.6s, fitting them with new cockpits equipped with GR.7 night attack avionics and, probably, a reshaped nose section to accommodate the GEC Systems FLIR and Marconi Zeus ECM equipment. The Hughes ARBS was removed, making the aircraft longer than the GR.7.

It soon became clear, however, that the handling characteristics of the GR.3/T.4/8 were totally different from those of the

Above: Although slightly heavier and longer than the GR.7, the T.10 flew just like its counterpart. ***(RAF)***

GR.7/9 and would not meet the RAF's requirements for training future Harrier pilots. Having already evaluated the then in-service American TAV-8B, the RAF issued a requirement based on that airframe but with the avionics, night attack and operational fit of the GR.7, powered by the Rolls-Royce Pegasus 105 engine.

Left: T.10 ZH662/110 in the hover. ***(RAF)***

Below: T.10 on strength with No.800 Squadron. ***(Author)***

Above: Head-on view of a T.10. ***(Author)***

Left: T.10 ZH653/TX001 took its maiden flight from Warton Aerodrome on 7 April 1994. ***(BAe Systems)***

An order for fourteen Harrier T.10s was placed on 28 February 1990, although this figure was later reduced to thirteen before the final contract. The first Harrier T.10, ZH653/TX001, took its maiden flight from Warton Aerodrome on 7 April 1994 and was then passed to BAe Dunsfold for trials. The final airframe, ZH665, was delivered to No.20(R) Squadron – the Harrier OCU at RAF Wittering – on 26 October 1995.

No.20(R) was the main user of the type in service, with seven aircraft on strength, while the three operational Harrier squadrons each had one T.10. The Harrier OCU flew its first T.10 sortie on 1 March 1995 and was instrumental in developing the aircraft to maximise its benefits for the service.

Although slightly heavier and longer than the GR.7, the T.10 flew just like its counterpart and was rock steady at low level. The only difference was in vertical work, where it did not match the VSTOL performance of the GR.7. However, unlike their American TAV-8 counterparts, the T.10s were fully combat capable.

The front cockpit was laid out exactly like the GR.7, except for a fuel proportion switch that regulated flow from the aircraft's internal tanks, which, due to the extra cockpit, differed in size from those of the GR.7. The rear cockpit featured two MPCDs, a throttle and a stick, with the remaining displays and controls intended for monitoring or emergency use.

Although the T.10 had a slightly lower rear vantage point than the T.4/8, and the

Centre left: The T.10 did not have the same VSTOL performance as the GR.7. ***(BAe Systems)***

Left: Harrier T.12 ZH657/105 of No.800 NAS. ***(RAF)***

Above: Harrier T.10 ZH658 in formation with a pair of GR.7s *(BAe Systems)*

Left: A No.800 Squadron GR.9 is prepared for launch. *(Royal Navy)*

view into the front cockpit was somewhat restricted, along with the absence of hydraulic gauges in the rear cockpit, these posed few real problems.

Nine T.10s received the same Joint Upgrade and Maintenance Programme (JUMP) as the GR.9s and were designated Harrier T.12. Unlike the GR.9, however, they retained the Pegasus 105 engine. A further upgrade of selected airframes with the Pegasus 107 engine led to the T.12A designation.

Joint Force Harrier

As part of the ongoing rationalisation of the UK's Harrier assets, both RAF and Royal Navy units were amalgamated under one banner: the 'Joint Force Harrier'. Joint Force Harrier was established on 1 April 2000 in response to proposals brought forward by the UK's Strategic Defence Review. Originally called 'Joint Force 2000', it combined the Royal Navy's Sea Harrier F/A-2 squadrons with the RAF's Harrier GR.7/7A squadrons under a single command structure within RAF Strike Command.

This force was designed to be deployable from both Invincible-class aircraft carriers, Royal Air Force stations and deployed air bases. The Royal Navy's contribution to the force was the Sea Harrier, previously part of Naval Air Command. However, with the retirement of the Sea Harrier in 2006, the force then consisted entirely of Harrier GR.7s and the upgraded Harrier GR.9s.

In 2006, No.3 Squadron converted to the Eurofighter Typhoon, surrendering its aircraft

Left: No.800 Squadron Harrier on finals to land aboard HMS *Ark Royal*. *(Royal Navy)*

Right: The Naval Strike Wing reverted to the identity of No.800 NAS, flying the Harrier GR.9 and GR.9A variants. ***(Royal Navy)***

to the Fleet Air Arm and allowing No.800 Naval Air Squadron to reform. At the same time, the size of operational squadrons was reduced from twelve aircraft to nine, enabling No.801 Naval Air Squadron to convert from the Sea Harrier.

On 31 March 2006, No.800 Squadron was re-commissioned at RAF Cottesmore with the Harrier GR.7/7A. The unit was followed by its sister squadron, No.801, on 8 March 2007, with both units receiving the ultimate sea-going Harrier: the GR.9/9A.

On 9 March 2007, with the reformation of 801 NAS, the 'Naval Strike Wing' was formed. This saw elements of both naval squadrons amalgamated into a single operational unit for deployment either on land or aboard the Royal Navy's two aircraft carriers.

The GR.7s were given minor improvements for carrier operations, including a cockpit-mounted GPS receiver—presumably the Garmin 100 as used in the Sea Harrier—software upgrades to the aircraft's INS to ease alignment on a rolling carrier deck, a new IFF transponder, and relocation of the water replenishment point from the top of the aircraft to inside the undercarriage bay, allowing flight-deck crews easier and safer access.

On 1 April 2010, the Naval Strike Wing reverted to the identity of No.800 NAS, flying the Harrier GR.9 and GR.9A variants. Following the decision to withdraw the

Right: ZD431/43A of No.800 NAS. ***(Royal Navy)***

Below: No.3(AC) Squadron Harrier lands aboard HMS ***Ark Royal.*** ***(Royal Navy)***

Above: A No.800 Squadron Harrier lands on a very wet deck. ***(Royal Navy)***

Harrier from service in the 2010 Strategic Defence and Security Review, a Harrier GR.9 made its final flight from a Royal Navy aircraft carrier, HMS *Ark Royal*, on 24 November 2010—also marking the last time an aircraft flew from the carrier, which was then slated for retirement.

End of the Line

On 31 March 2010, No.20 Squadron RAF, the Harrier OCU, was disbanded, and No.IV Squadron was also disbanded and reformed as No.IV (Reserve) Squadron at RAF Wittering. All Harrier GR.7 aircraft were retired by July 2010, and the Harrier GR.9 was expected to remain in service at least until 2018.

However, on 19 October 2010, it was announced in the Strategic Defence and Security Review that the Harrier was to be

Above: A mass flypast to commemorate the end of the Harrier in RAF service. ***(RAF)***

retired by April 2011. In the long term, the F-35B Lightning would operate from the Navy's two new Queen Elizabeth-class aircraft carriers.

The decision to retire the Harrier was controversial, with some senior officers calling for the Panavia Tornado to be retired instead. The decision left Britain without any fixed-wing aircraft capable of flying from the Navy's aircraft carriers.

The Harrier fleet's last operational flights occurred on 15 December 2010, with flypasts over numerous military bases. In November 2011, the Ministry of Defence sold seventy-two Harriers, along with spare parts, to the US Marine Corps for £116 million. The aircraft were to be used as a source of components for the AV-8B Harrier.

RAF HARRIERS AT WAR

Belize Operations

Harrier GR.3s had been deployed to Belize in 1975 in an effort to diffuse tensions in the region. Later, when tensions again rose, a four-aircraft detachment - later redesignated No.1417 Flight - remained at Belize International Airport for the next sixteen years until the threat had diminished. Although No.1417 Flight was disbanded in July 1993, a Harrier deployment was planned to take place two months later as a show of force. Thus, six GR.7s from No.IV Squadron departed from RAF Laarbruch for Belize, arriving on 8 September, and they remained in-country for two weeks before returning home.

The Gulf War Aftermath - Operation Warden

Although the RAF's Harriers were in service at the time of the 1992 Gulf War, because the aircraft had not been fully cleared for operations, they played no part in the conflict. However, they were available for a peacekeeping role in the period after the war had ended. Set up as a direct result of the aftermath of the Gulf War, 'Operation Warden' was the British contribution to the United Nations efforts within 'Operation Provide Comfort', under which the UN provided safe and protected 'havens' for the Kurds. These areas were policed by the air forces of the United States, the UK and France, former western partners in Desert Storm.

After the war, the initial British force was provided by RAF Coltishall's Jaguar Wing, and their eighteen-month deployment was passed on to the Harrier GR.7 in April 1993, giving further credence to the aircraft's growing capabilities. Eight Harrier GR.7s, drawn from No.3 and No.IV(AC) Squadrons based at Laarbruch in Germany, made the trip out to Incirlik AFB in Turkey, together with sixteen aircrew and other supporting staff, departing on 2 and 8 April, four aircraft flying out each day. Their principal tasks were to fly 'armed reconnaissance', providing photographs of a wide variety of targets in the northern 'no-fly' zone sector of Iraq and looking in particular for SAM and radar sites, fuel and ammunition dumps, and troop movements and concentrations.

With the introduction of the Harrier GR.5, the traditional reconnaissance role associated with No.IV(AC) Squadron was 'lost' with the passing of the GR.3 from squadron service, and was revived for the Warden detachment. The Harrier's traditional reconnaissance role was intended mainly for low-level work, and as many of the Warden operations were to be from medium altitude, the RAF purchased new Vinten VICON 18-603 OP(4) pods, which contained a 91cm LOROP (Long-Range Oblique Photography) camera for use at the new flight level. The Vinten pods also offered a movable nose camera as well as horizon-to-horizon coverage. Modes available included vertical, tactical, stand-off and long-range oblique, and each aircraft required 650 man-hours for the necessary modifications to enable it to carry the pods.

Pilots found the simplest method to track

Left: Armed with BL755 CBUs, AIM-9 Sidewinders and Phimat pod, a GR.7 returns to Incirlik. ***(RAF)***

Right: Ground crew prepare a GR.7 for an Operation 'Warden' mission. ***(RAF)***

the camera angle was to draw a chinagraph pencil line across the side of their canopies as a rough guide to where the system was 'looking'. In order to process the information, a portable Reconnaissance Interpretation Centre (RIC) was borrowed from No.41 Squadron at Coltishall, before equipment from the original RICs of GR.3 days was reinstated.

The RICs were able to quickly process and analyse the 550 images from the film packs. As many of the GR.7 pilots were already experienced reconnaissance operators from their GR.3 days, only a short work-up time was needed for them to hone their skills, whilst others new to the role underwent an intensive work-up period which included gaining their night tanking and night close formation qualifications.

The aircraft themselves were brought up to a high maintenance standard, which included the addition of a FIN 1075G navigation system referenced to GPS, IFF changes, and internal software and hardware upgrades to allow the aircraft to carry US weapons. These changes became universally known as the 'Warden Standard' or 'Warden Fit'. In all, eighteen Harriers were so modified for the detachment, and this was outlined to a greater degree when all of the aircraft received an overall wash of a light grey ARTF (Alkaline Removable Temporary Finish) paint scheme, designed to make the machines less conspicuous when set against a predominantly blue sky, especially at medium altitude. Markings were non-existent, except for pale pink/pale blue roundels on the wings and intakes, with black (for aircraft from No.IV(AC) Squadron) or white (for No.3 Squadron) ID numbers. Tail codes were in white beginning with 'W' for Warden; from WA to WZ.

Below: A GR.7 en route to Incirlik for the UK. ***(Andy Suddards)***

Despite being the most war-ready aircraft in the RAF's Harrier fleet, these aircraft were not 'night capable', a situation that was rectified under the MOD-95 programme which gave all the Warden aircraft the 'night fit' and the non-Warden aircraft the 'war fit'. The Warden pool of aircraft were also not selected initially to receive the 100% LERX, retaining their 65% option in the interests of keeping the aircraft to the same standard.

The Harriers flew patrols over Iraq fully armed. The principal weaponry included the

BL755 CBU, the US-manufactured CBU-87 CBU, the Canadian-built 70 mm high velocity CRV-7 rockets housed in a nineteen-round LAU 5003 B/A pod, and the AIM-9 Sidewinder AAMs. The standard fit was therefore either two CBUs or two CRV-7 pods and two AIM-9L Sidewinders. Self-protection was aided by the Zeus ECM system, with either a wing-mounted Phimat chaff dispenser or a BOL-304 launcher replacing the Sidewinder rail, as well as the under-fuselage Tracor AN/ALE-40 flare dispensers. Endurance was enhanced by the addition of 11,800 lb of fuel carried in two underwing tanks.

Aircrews were drawn from each of the operational units as well as from No.20(R) Squadron, the Harrier CCU (which participated in 1994). They worked on a two-month rotation basis, with each pilot flying around six two-and-a-half-hour sorties during his working week. Each sortie into Iraq was treated as a full combat hop, crews being 'sanitised' of insignia or personal possessions and carrying only survival gear and a pistol.

Operating in pairs, using call signs such as 'Spitfire' and 'Hurricane', the aircraft were assigned from twelve to eighty-one specific targets as well as other 'targets of opportunity', which presented themselves. The package that flew in support of the Harriers included USAF F-15 or F-16 fighters, AWACS, EF-111 jammers and SEAD suppressers as necessary.

Only one aircraft was lost during the Warden detachment—ZD432/WF belonging to No.IV(AC) Squadron, which suffered an engine surge while refuelling from a VC-10. The pilot ejected near Dahluk and was looked after by local tribesmen, following which he was picked up by a USAF CSAR helicopter.

Above: A flight of GR.7s formate upon a VC.10 tanker.

As previously noted, the Warden aircraft received an overall light grey ARTF paint scheme, which soon began to peel and flake, as well as taking wear and tear from technicians and engine staining. Coupled with this was the new operational use of the Harrier at medium level. The RAF therefore established a requirement, under the aegis of MOD-95, to give the entire Harrier fleet a standard fit and colour scheme and bring all aircraft to the same equipment standard.

The final eighteen aircraft off the Dunsfold production line were given the new 100% LERX, and these aircraft were initially delivered to No.IV(AC) Squadron in Germany. MOD-95 also introduced a new fleet-wide camouflage scheme in the same pattern as the original greens, but with Dark Sea Grey upper surfaces and dark camouflage grey lower surfaces.

During Operation 'Deny Flight', a mix of ARTF and MOD-95 painted aircraft operated from Gioia del Colle in Italy. These aircraft now featured two-digit build numbers on their tailfins, replacing the old individual squadron codes. Because of the policy of rotating airframes around the squadrons and detachments, it was discovered that the composite materials did not take well to having large portions removed for the application of squadron markings, then repainted only for these to be removed again as the aircraft changed unit. Therefore, individual unit markings were placed on suitably removable panels, usually on the intakes and on the top of the tailfin, which only needed to be swapped as new aircraft arrived.

Left: Getting a clean-up at Incirlik, and note the protector over the ARBS. ***(RAF)***

Right: Already weary-looking in its ARTF grey, a GR.7 on the ramp at Gioia del Colle. ***(Author's Collection)***

Below right: ZD405/34 in its MOD-95 camouflage scheme at Gioia del Colle. ***(Author's Collection)***

Balkans Operations - Operation Deny Flight

In response to the deteriorating situation in the Balkans, new 'no-fly' zones were set up over Bosnia-Herzegovina under the aegis of the UN-led Operation Deny Flight. As with their previous deployment to Operation 'Warden', the Harriers once more relieved a Coltishall Jaguar detachment, this time at the Italian air base of Gioia del Colle.

Twelve Harrier GR.7s from No.IV(AC) Squadron took up station at Gioia. The aircraft themselves, although nominally on strength with the unit based in Germany, came from a newly established pool of available airframes drawn from all the operational units. The pooled aircraft were recognisable by their tail codes, which were now non-squadron related but reflected the aircraft's build numbers. Thus, ZD376 had a white, two-digit tail code of '24'. The complement was soon reduced to nine as experience dictated the size of the force.

The primary role of the Harrier in Deny Flight was directed by the UN Protection Force (UNPROFOR), and their main task was that of providing Battlefield Air Interdiction (BAI). Secondary roles included Close Air Support, usually operating with a Forward Operating Air Controller (FOAC) on the ground, and reconnaissance - both vertical and stand-off - all of which the Harrier had proved it could achieve with considerable success.

The aircraft in the pool were prepared for duty with similar equipment fits to that of the 'Warden Standard' and fitted with an enhanced EW system supplied by BAe at Dunsfold to meet an increased SAM threat.

Below: Harrier GR.7 ZG376/24-note the presentation of the serial number and the rather shabby paintwork. ***(Author's Collection)***

Initially, the camouflage scheme for the aircraft remained that of light grey ARTF, although by now the paintwork was looking very messy. Mixed in with the ARTF aircraft were examples of the MOD-95 two-tone permanent grey scheme, and by the end of the detachment the mix had reversed to more MOD-95 than ARTF aircraft.

For the light grey aircraft, markings continued to be at a premium, with pale pink and pale blue roundels, white two-digit tail codes and a much-reduced black ID number. Subsequent MOD-95 aircraft that rotated through Gioia wore the smart Dark Sea Grey upper surface and Dark Camouflage Grey lower surface scheme, with full-colour red and blue roundels on the wings and intakes, a small swept red and blue fin flash, white two-digit tail codes and standard-size black ID numbers.

Self-protection was evident again in the shape of Phimat or BOL chaff launchers, underfuselage AN/ALE-40 flare dispensers, along with two Sidewinder AAMs. Offensive

Above: ZG857/89 toting BL755 CBUs, and note the mission symbols. ***(RAF)***

weaponry included the BL.755 CBU, CRV-7 rocket pods and 1,000lb unguided iron bombs. As the need to make 'surgical' strikes on Serb positions became an increasing possibility, it was decided to bring 454 kg laser-guided bombs into use. Stand-off designation was to be provided by two TIALD laser Jaguar GR1.Bs on 48-hour standby at Coltishall.

Within a month of their arrival, the time for action came. After a Bosnian Serb mortar attack on a marketplace in Sarajevo on 28 August killed thirty-seven people, NATO responded with Operation 'Deliberate Force', which involved a total of eighty aircraft. The Harriers' first involvement came at 1am BST on the morning of 30 August, under the codename 'Operation Vulcan', when nine GR.7s, each carrying two 454kg LGBs and supported by TIALD-equipped Jaguar GR1.Bs, attacked Serb radar installations. This was followed about two hours later with attacks on an ammunition dump at Lukavica and a factory at Vugosca.

Further attacks were carried out on 1 September, followed by a brief respite for the Serbs to comply with UN resolutions and allow aircraft to examine areas for BDA (battle damage assessment). As there was no such compliance, the air strikes resumed on 5 September, as the Serbs continued to flout the NATO order to remove their heavy weapons. The Harriers ranged out to Pale attacking military installations, and also undertook strikes at Tuzla, Gorazde and Mostar, before NATO called a halt to the bombing on 14 September.

During that time, the Harriers had flown a total of 144 BAI, CAS and reconnaissance sorties, and by December 1995 the Harrier Force had flown some 758 sorties, 273 of which were for training purposes, consuming over 1,160 flying hours. The force dropped forty-eight LGBs and thirty-two free-fall 1,000 lb bombs, achieving an eighty-five per cent success rate in either totally destroying or severely damaging its targets—proof positive that the Harriers had the cutting edge.

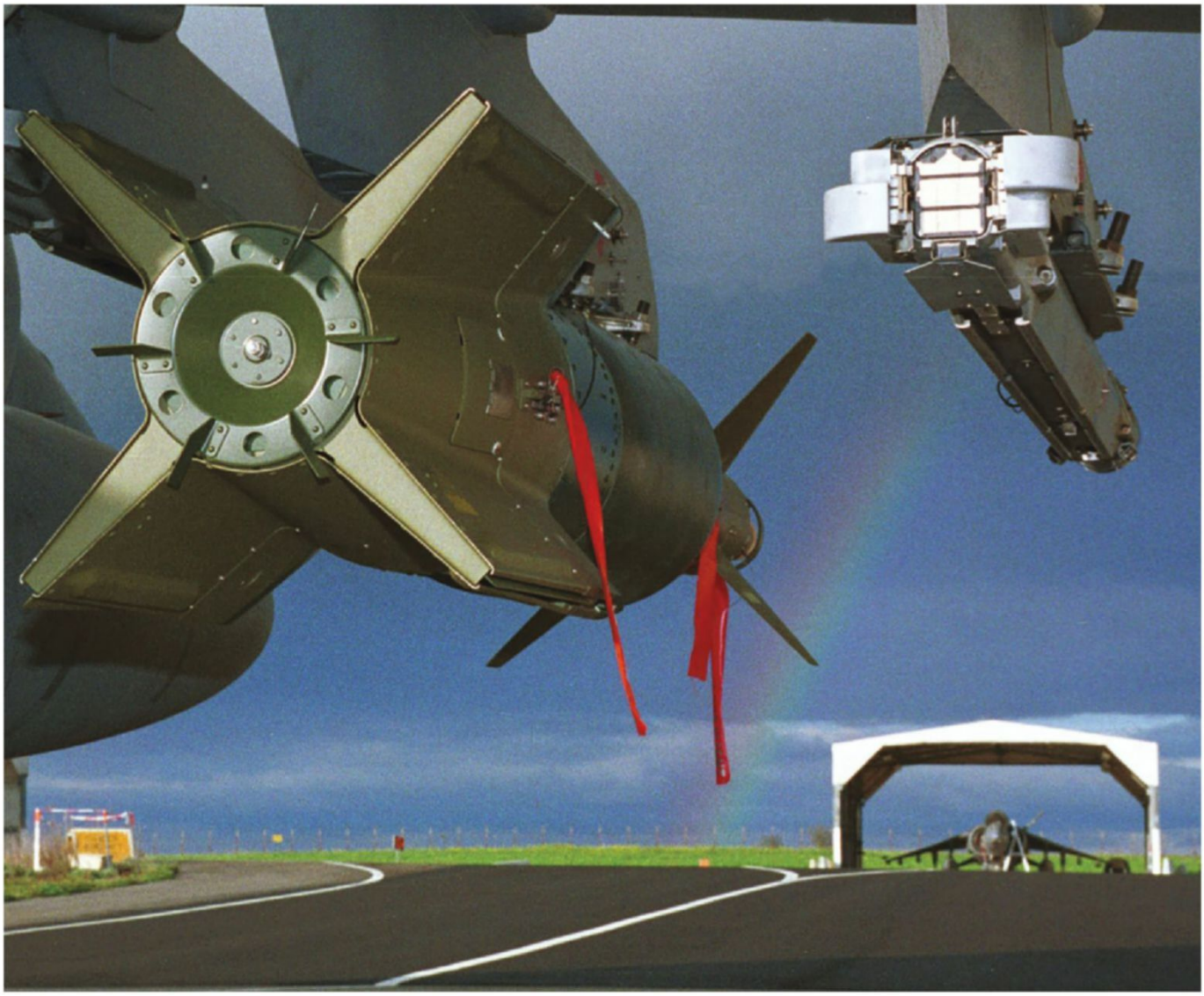
The complement of nine Harriers fell to six in January 1996, with two aircraft solely employed in the reconnaissance role. 'Deny Flight' became 'Decisive Edge' as peace efforts gathered momentum, and subsequently became 'Joint Endeavour' when, on 1 January, UNPROFOR changed its title to Implementation Force (IFOR). The Harrier detachment was once again relieved by Jaguars on 5 February 1997, with No.3 Squadron being the last to deploy to Gioia.

Operation Allied Force - Kosovo Harriers

The Harriers' mission in Kosovo began in 1999 with Operation 'Engadine', sharing the workload with Tornado GR.1s. The Harriers

Above left: Readied for a precision strike with TIALD and Paveway on board. ***(RAF)***

Left: A pair of GR.7s are readied for another 'Allied Force' operation. ***(RAF)***



Above: Paveway LGB on the wing pylon of a GR.7. ***(RAF)***

Left: Close in on the standard GR.7 'Allied Force' war fit. ***(RAF)***

were once again tasked with Battlefield Air Interdiction (BAI), Close Air Support (CAS) and reconnaissance, and when operations began on 25 March, the aircraft were again operating from Gioia del Colle in Italy and were heavily involved in attacks against Serbian forces in Kosovo.

During the course of the campaign, the RAF identified a number of shortcomings in the Harrier's arsenal. Independent stand-off laser designation was one of the major problems, as the Harrier Force had to rely on other assets to provide for their precision-guided munitions (PGMs). The solution was to integrate the Tornado and Jaguar-based TIALD pod onto the Harrier, and this was achieved by modifying one of the underfuselage strakes with an aerodynamic fillet to accept the TIALD pod.

A second problem was the need for a stand-off air-to-ground missile. On one occasion, Harriers aborted their attack and returned to their base in Italy without releasing their weapons. The following day, the Harriers were tasked to attack barracks that were home to an anti-aircraft unit, ammunition stores, man-portable surface-to-

Left: The TIALD pod, very effective with the Harrier Force. ***(RAF)***

Right: Vinten Vicon recce pod. ***(RAF)***

air missiles, mobile radar installations and self-propelled guns. Of the three targets attacked, the Harriers successfully destroyed two. This set the scene for the Harriers' involvement over the coming months.

The number of Harriers on station varied during the course of the campaign, and when Operation 'Allied Force' operations ceased on 10 June 1999 and 'Operation Joint Guard' came into effect, some sixteen aircraft were available. Subsequently, ten returned to the UK, and six remained as part of the new operational situation.

Operation Palliser - Harriers in Sierra Leone

The GR.7's next taste of action came with Operation 'Palliser'. In May 2000, six GR.7s from No.3 Squadron were embarked aboard HMS *Illustrious* off the coast of Portugal, participating in a NATO exercise, 'Linked Seas', in concert with Royal Navy Sea Harrier F/A-2s. On 8 May, the carrier was diverted towards Sierra Leone to assist with the unstable situation in the country, arriving in-theatre on 11 May. The first operational Harrier sortie was flown on 17 May, providing reconnaissance and reassurance during the UK's intervention. The Harriers all returned to RAF Cottesmore on 11 June 2000.

Right: On the ground at Al Jaber, and note the white GPS antenna on the spine. ***(RAF)***

Below: Flying the flag for the Operation 'Telic' Harrier detachment. ***(RAF)***

Above: ZD379/27 taxies out from Al Jaber. ***(RAF)***

Right: Sitting in a revetment armed with Paveways and Sidewinders, this Harrier is ready for its next mission. ***(RAF)***

Operation Telic - Iraqi Freedom Harriers

On 6 February 2003, in response to the continuing tension in the Gulf and growing concerns over alleged 'weapons of mass destruction', an RAF force package was dispatched to the region under the aegis of Operation 'Telic', part of the US-led Operation 'Iraqi Freedom', with the remit of bringing stabilisation to a beleaguered Iraq.

For this conflict, the RAF was better prepared than for the previous Gulf War, having learned hard lessons over the skies of Bosnia and Kosovo. Once again, Tornado and Harrier aircraft were at the forefront and acquitted themselves admirably in the unfolding events. RAF Cottesmore readied and dispatched an initial contingent of ten Harrier GR.7s to the Gulf, complete with their own autonomous laser designation tool in the

Right: Armed with a mix of dumb and smart weapons, a GR.7 taxies out. ***(RAF)***

Below: A trio of Harriers in the Al Jaber heat. ***(RAF)***

Above: Next to a HAS damaged in the Gulf War are a pair of GR.7s. ***(RAF)***

Left: Here you can see the 'additional' pylons fitted to the RAF Harriers. ***(RAF)***

form of the GEC Marconi TIALD pod, a range of Paveway bombs and the impressive AGM-65 Maverick. The latter was procured as a result of the Kosovo conflict, where the lack of a precision-guided stand-off weapon had become blatantly obvious.

The missile's autonomous guidance systems gave aircrews launch-and-leave capability at a wide range of distances and speeds. Because of its accuracy and lethal warhead, Maverick provided a high single-pass kill probability. Unlike the Tornado GR.4s, the Harriers did not receive a new paint scheme for Operation 'Telic'. From the outset of the conflict, the RAF's Harriers were slated to operate at medium levels and retained their permanent two-tone grey scheme, comprising Dark Sea Grey upper surfaces with Dark Camouflage Grey side and undersurfaces, with red/blue national markings—a scheme applied to all RAF attack aircraft during the late 1990s.

Harrier GR.7s were heavily involved in close air support missions across Iraq. The Maverick missile was fired in anger for the first time against a mobile SCUD launch site some 200 miles into Iraq during the first days of the conflict, when a pair of AGM-65s successfully engaged and destroyed their target.

Operating either with a specific tasking or on a 'flying alert' basis, waiting to be called in by on-the-spot ground commanders, the Harriers maintained an almost constant presence over the battlefield. A normal offensive load would include the 1,000lb Paveway II or 2,000lb Enhanced Paveway III, 500 or 1,000lb iron bombs, RBL-755 cluster weapons, AGM-65G2 Maverick missiles, Sidewinder AAMs, a TIALD pod and up to

Left: The classic 'Telic sharksmouth' applied, no doubt to keep up with the co-located USAF A-10s. ***(RAF)***

Right: Both AGM-65 Maverick and BL755 CBUs are fitted here. ***(RAF)***

four Celsius Tech BOL chaff and flare launchers. Ex-Jaguar reconnaissance pods were also integrated onto a number of Harriers so they could be used in dual CAS and reconnaissance roles if needed.

Once the coalition had gained total air supremacy, refuelling tankers were able to circle over Iraqi skies, enabling the fighter bombers to take on enough fuel to reach northern targets. For use with the Paveway precision-guided munitions, the Harriers carried TIALD pods. This second-generation laser designator initially entered service while still in development during the Gulf War in 1991. The pod was later modified to provide a TV sensor in addition to the infrared sensor.

The Paveway II LGB was essentially a 1,000lb general-purpose bomb with a seeker head fitted to the nose and movable guide fins fitted to the tail. A laser is used to designate the required target, and the bomb's guidance package then steers the weapon to the source of the reflected laser energy. The Paveway III was fitted with a 2,000lb hardened target penetrator warhead, steered by an improved precision-guidance package that follows the laser designation of a target.

Enhanced Paveway (EPW) entered service in 2001, and the larger EPW III entered service in late 2002. Both EPW II and EPW III utilise the same warheads and fin sections; however, they have a modified guidance section to accommodate a Global Positioning System Aided Inertial Navigation System (GAINS).

During the Battle of Basra, a key Iraqi

Right: A mix of 1,000lb Paveway II and iron bombs. ***(RAF)***

Below: The destructive AGM-65 Maverick. ***(RAF)***

Above: Note the BOL chaff dispenser on the outer pylon. ***(RAF)***

Left: Messages from home. ***(RAF)***

city, Harriers conducted multiple strike missions against Iraqi fuel depots to cripple enemy ground vehicles. Other priority targets for the Harriers included tanks, boats and artillery. By the end of the campaign, Harrier pilots had flown several hundred missions over Iraqi territory, with some sorties lasting up to eight hours. On their first few missions they had taken out strategic targets, but the majority of the war was spent providing close support for troops on the ground. The Harriers began to return home to RAF Cottesmore in late April 2003.

Operation Herrick - Harriers in Afghanistan

The RAF's involvement in Afghanistan dates back to October 2001, when RAF aircraft provided reconnaissance and air-to-air refuelling capabilities in support of US strike aircraft on Operation Enduring Freedom. During May 2004, barely a year after returning from Operation Telic, the Harriers of the JFH were tasked to relieve the American AV-8Bs operating in Afghanistan.

As part of the UK's ongoing operations in the region under the designation 'Operation Herrick', elements of No.3(AC) Squadron were to take up residence at the former Soviet airbase at Kandahar. On 24 September 2004, six re-engined Harrier GR.7As left RAF Cottesmore for a deployment that would eventually involve all JFH units and last some five years.

Amongst the weapons deployed with the Harriers were the AGM-65G2 and AGM-65JX Maverick, the 1,000lb Enhanced

Left: GR.7s and Paveway - a deadly combo. ***(RAF)***

Above: Down the barrel of a Paveway II. ***(RAF)***

Left and below: Creating a sharksmouth, first by masking…

…then some cutting out…

…and some paint… ***(RAF)***

Above: Operation 'Herrick' Harrier on station with TIALD and Paveway LGBs. ***(RAF)***

Paveway II, CRV-7 rockets and the JRP pod. CRV-7 is an unguided ground attack rocket. Each pod contains nineteen rockets, giving a total of thirty-eight per aircraft, and going some way to mitigate the lack of a gun for strafing targets. The pilot could select the option to fire one rocket or any multiple. No cluster bombs were employed on humanitarian grounds.

After flying a number of familiarisation and Ground Close Air Support (GCAS) missions, the first bomb dropped by a Harrier took place on 3 May 2005, when an EPW II was released—marking the beginning of a bombing and support

Right: A Harrier beneath one of the temporary shelters erected for Operation 'Herrick'. ***(RAF)***

Below: A Harrier launches flares on a patrol over Afghanistan. ***(RAF)***

Above: A GR.9 with Sniper and recce pods takes on fuel over Afghanistan. ***(RAF)***

campaign that would last until the aircraft returned home.

Although no Harriers were damaged in air operations, two were hit on the ground during a rocket attack on Kandahar airfield in October 2005. One aircraft was repaired, but the other-ZD469, a GR.7A-was returned to Cottesmore for use as a ground instruction airframe.

During the Harriers' time in Afghanistan, the size of the force varied depending on 'surges' and operational requirements. It became apparent that the TIALD pods were

Left: Armed with CRV-7 and Paveway, a GR.9 on patrol. ***(RAF)***

Below: A GR.9 fires off a flare. ***(RAF)***

Right: The first bomb dropped by a Harrier took place on 3 May 2005, when an EPW II was released. ***(RAF)***

no longer suitable for the environment in which the Harriers were now fighting. Although very effective as an air interdiction system, the Harrier Force needed something geared more toward urban CAS, and so the Lockheed Martin 'Sniper' pod was added to the aircraft's inventory.

The recently formed 'Naval Strike Wing' arrived on station in September 2006 to undertake their first operational forays since relinquishing their Sea Harriers. During the period of October 2006 to January 2007, No.800 NAS dropped more ordnance than any other unit in a comparable timeframe.

No.1(F) brought the first GR.9As to the war zone in January 2007, and it was the Naval Strike Wing that were the first to operate the further upgraded Harrier GR.9A Cap C+ in Afghanistan, with its new aiming system for Paveway III and the integration of Paveway IV, along with RAIDS, Successor IFF, the advanced Sniper Mk.2+, Terma EW and the Helmet Mounted Cueing System. The Terma pod provided more defensive flares than the usual internal load, and a missile launch queue to the pilot.

During their second deployment, the Naval Strike Wing was the first to drop the new Paveway IV on 28 November 2008. The Paveway IV changed the way the Harrier operated, as not only could the weapon be guided to its target using a laser through the Sniper Advanced pod or from the ground, it could also be delivered onto precise GPS coordinates. The weapon was also cockpit programmable, allowing the pilot to tailor the effect depending on the target.

The main area of operations for the Harrier was over the Helmand Valley,

Right: The Lockheed Martin Sniper pod. ***(RAF)***

Below: Harrier GR.9s are prepared for another Operation 'Herrick' sortie. ***(RAF)***

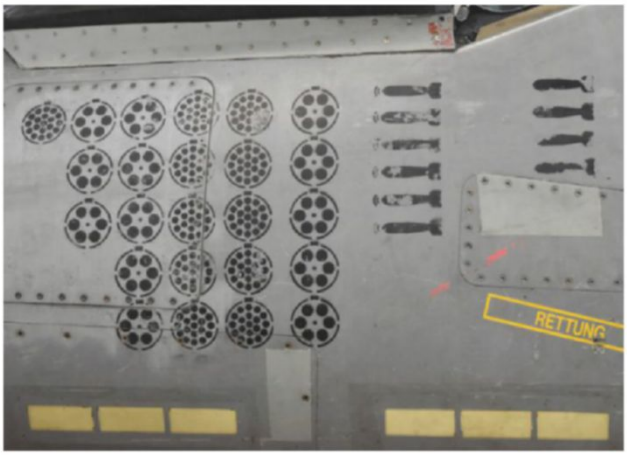
Above: A GR.9 banks away with Vinten Vicon recce pod, Sniper pod and CRV-7 rocket packs. ***(RAF)***

Left: Engine change at Kandahar. ***(RAF)***

supporting the Army and Royal Marines as well as other coalition troops. At ninety miles from Kandahar, flying time was usually about 15-20 minutes. However, the Harrier was often tasked or re-tasked all over the country, with jets operating over places such as the Khyber Pass, showing the full potential and reach of the aircraft.

By the end of 2008, Tornado GR.4s were slated to take over from the Harriers, and the JFH deployment was preparing to wind down. However, the ramps to receive the replacement detachment were not ready, and the Tornadoes themselves needed to be outfitted with the Terma pod in order to

Below: ZG505/76 comes in to land at Kandahar. ***(RAF)***



Above: Over the Afghan desert, a GR.9 fires off a flare. ***(RAF)***

Above right: Operation 'Herrick' mission markings. ***(RAF)***

operate in the high infrared threat area. Therefore, the Harriers' stay was extended.

During this period, a further Harrier was lost when its pilot, attempting to land while a civilian aircraft was getting airborne, crashed at Kandahar. The pilot ejected safely. The Tornadoes eventually began to arrive in a phased handover commencing on 14 June 2008, and the final Harrier sortie took place on 22 June 2009, with the final six deployed aircraft returning to the UK on 23 and 24 June.

By the end of their five years in theatre, the Harriers had flown over 8,557 sorties in 22,771 flying hours, offering GCAS and tactical reconnaissance support to NATO and coalition forces.

Right: Paveway IV aboard a GR.9. ***(RAF)***

Below: Armed with four Paveway LGBs and a Sniper pod, a GR.9 waits on the ramp at Kandahar. ***(RAF)***

Harrier II
IN DETAIL

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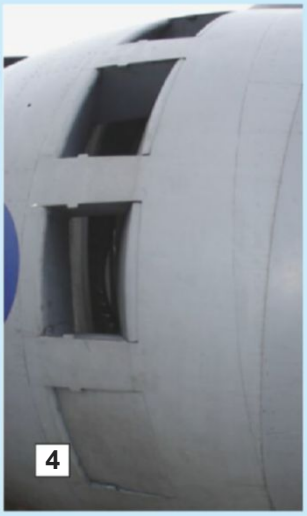
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Harrier GR.7

1. Nose section with Zeus antennae.
2. ARBS fairing.
3. Intake blow-in doors with IFR probe.
4. Blow-in doors detail.
5. LERX detail.
6. Aden gun pack (empty).
7. Canopy rear aspect.
8. Spine and LERX.
9. Upper wing.
10. BOL forward aspect.
11. Wing pylon with drill Sidewinder and BOL chaff launcher.
12. Wingtip ECM and puffer jet fairing.
13. Wing pylon.
14. BOL rear aspect.
15. Nose wheel port side.

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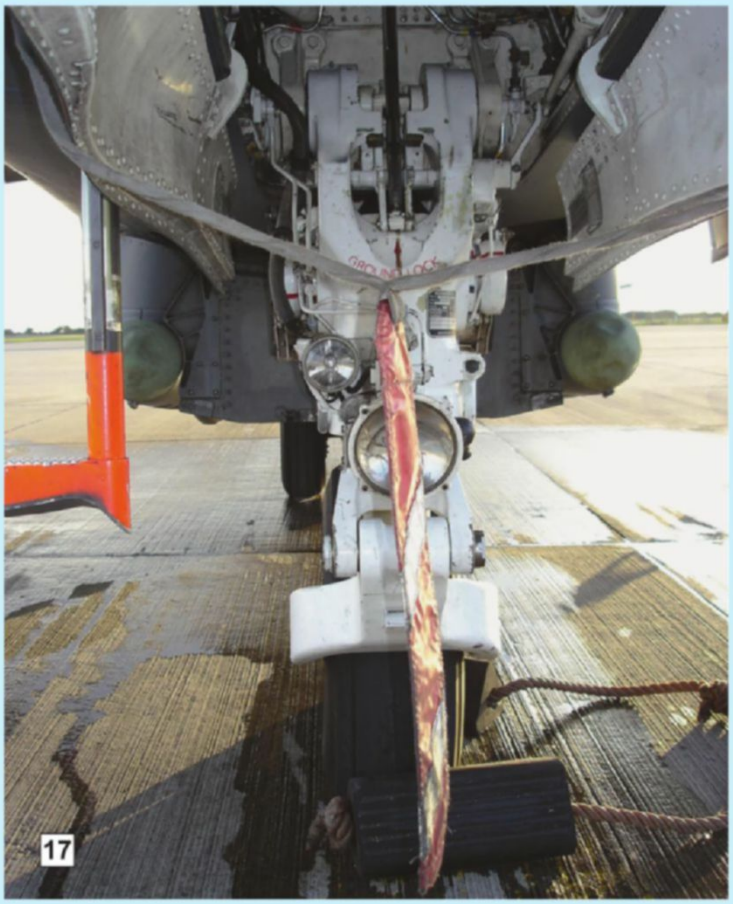
Harrier II
IN DETAIL *continued*

16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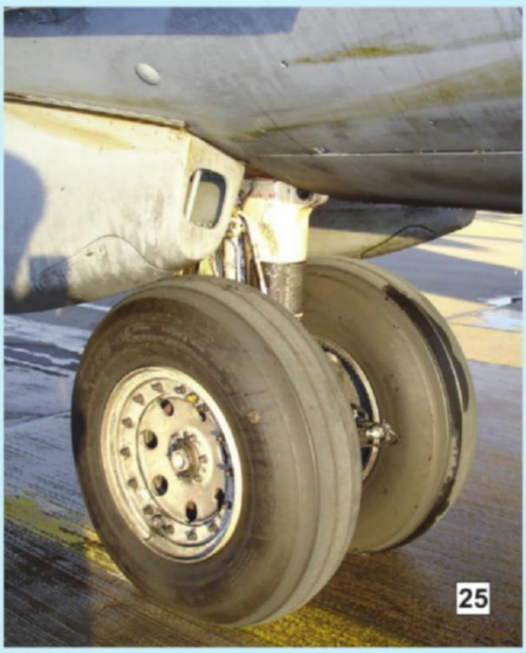


16. Nose wheel starboard side.
17. Nose wheel head-on aspect.
18. Forward side of LID (Lift Improvement Dam).
19. Nose wheel bay.
20. Rear engine nozzle.
21. Airbrake.
22. Pegasus engine fan.
23. Forward engine nozzle.
24. Rear nozzle heat deflector.
25. Main wheel side aspect.
26. Main wheel rear aspect.
27. Outrigger leg and wheel.
28. Outrigger wheel housing.
29. Tail boom detail.
30. Tail ECM antennae.

Harrier II
IN DETAIL *continued*

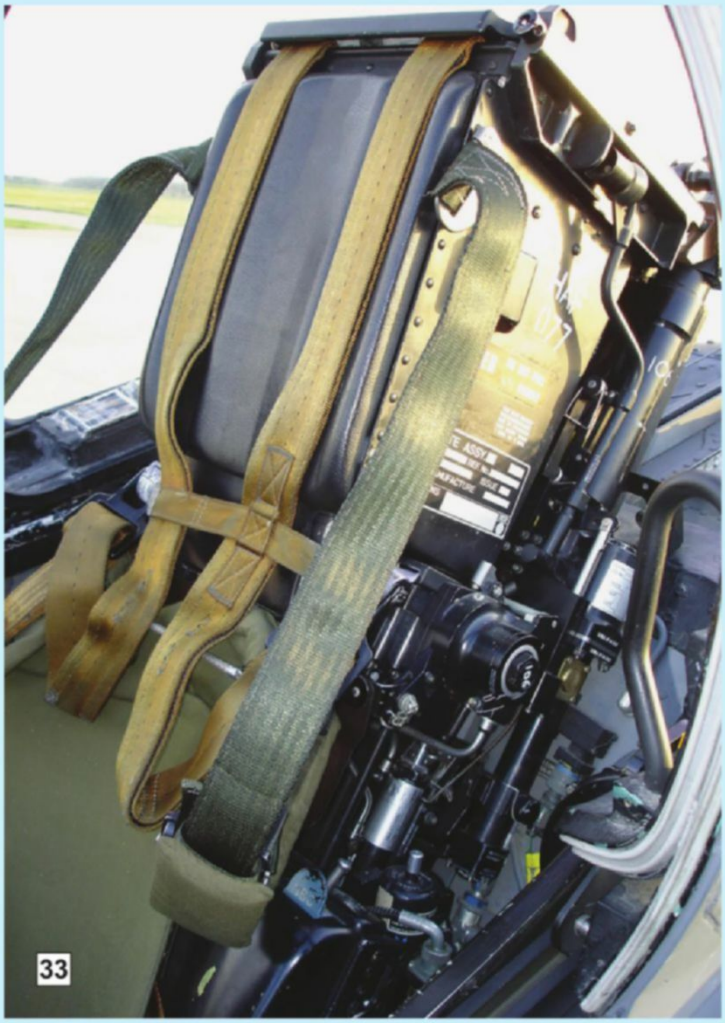
31

32

31. Front cockpit panel.
32. Cockpit displays.
33. Ejection seat head box.
34. Area behind ejection seat detail.

Harrier T.10

35. Intake and blow-in doors.
36. Side opening canopy detail.
37. MDC chord detail.
38. Forward fuselage detail.
39. Rear cockpit fairing.
40. ARBS and Zeus nose detail.
41. Refuelling point.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FLT LT M HASSELL
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FLT LT M HASSELL
FLT LT S B KILBY
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FLT LT M HASSELL
FLT LT S B KILBY
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Harrier II
IN DETAIL *continued*

42

43

44

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46

47

42. Under fuselage strake.
43. Undernose puffer vent.
44. Wing tank forward aspect.
45.. Cockpit instrument panel.
46. Wing tank connection to pylon.
47. Wingtip puffer jet and ECM fairing.
48. Wing tank connection points.
49. Tail boom detail.
50. Upper wing detail.
51. Wing tank upper aspect.
52. Ejection seat.

Harrier Specifications

Crew:	1
Length:	46ft4in (14.12m)
Wingspan:	30ft4in (9.25m)
Height:	11ft8in (3.56m)
Empty weight:	12,500lb (5,670kg)
Gross weight:	15,703lb (7,123kg)
Max take-off weight:	31,000lb (14,061kg); STO 18,950lb (8,596kg)
Powerplant:	1× Rolls-Royce Pegasus Mk105 turbofan engine with water injection
PERFORMANCE	
Maximum speed:	662mph (1,065km/h)
Combat range:	300nmi (350mi, 560km)
Ferry range:	1,758nmi (2,023mi, 3,256km) with 4× drop tanks
Service ceiling:	50,000ft (15,000m)
Rate of climb:	14,715ft/min (74.75m/s)
ARMAMENT	
Guns:	2× empty ADEN cannon pods under the fuselage
Hardpoints:	8 (under-wing pylon stations 1A and 7A are intended for air-to-air missiles only) with a capacity of 8,000lb (3,650kg) of payload, with provisions to carry combinations of:
Rockets:	LAU-5003 rocket pods (19× CRV7 70mm rockets each) or Matra rocket pods (18× SNEB 68mm rockets each)
Missiles:	4× AIM-9 Sidewinders, 4× AGM-65 Maverick
Bombs:	Paveway II/III/IV, Enhanced Paveway II/II+ series of laser-guided bombs, unguided 540lb and 1,000lb (240kg and 450kg) bombs (including 3kg and 14kg practice bombs)
Other stores:	2× auxiliary drop tanks or reconnaissance pod (such as the Joint Reconnaissance Pod)
Recce/targeting pods:	TIALD, DJRP, Sniper. These would replace the ADEN gun packs when mounted

Harrier Variants

GR.5 The GR.5 was the RAF's first model of the second-generation Harrier and differed considerably from the USMC AV-8B in terms of avionics, armaments and countermeasures. Forty-one GR.5s were built.

GR.5A The GR.5A was a minor variant, incorporating design changes in anticipation of the GR.7 upgrade. Twenty-one GR.5As were built.

GR.7 The GR.7 was an upgraded GR.5 with Zeus ECM and avionics upgrades. The first GR.7 conducted its maiden flight in May 1990 and made its first operational deployment in August 1995 over the former Yugoslavia.

GR.7A The GR.7A featured an uprated Pegasus 107 engine. GR.7As were later upgraded to GR.9 standard with the designation GR.9A.

GR.9 The GR.9 was an upgrade of the GR.7, focused on avionics and weapons. Later upgraded under the JUMP programme.

GR.9A The Harrier GR.9A was an avionics and weapons upgrade of uprated GR.7As. All GR.9s were capable of accepting the Mk107 Pegasus engine to become GR.9As.

T.10 The Harrier T.10 was a two-seat training variant based on the USMC TAV-8B. Unlike their American counterparts, the T.10s were fully combat-capable.

T.12 Update of the trainers to accompany the GR.9. Nine T.10 aircraft received the JUMP update; however, these retained the less powerful Pegasus 105 engine.

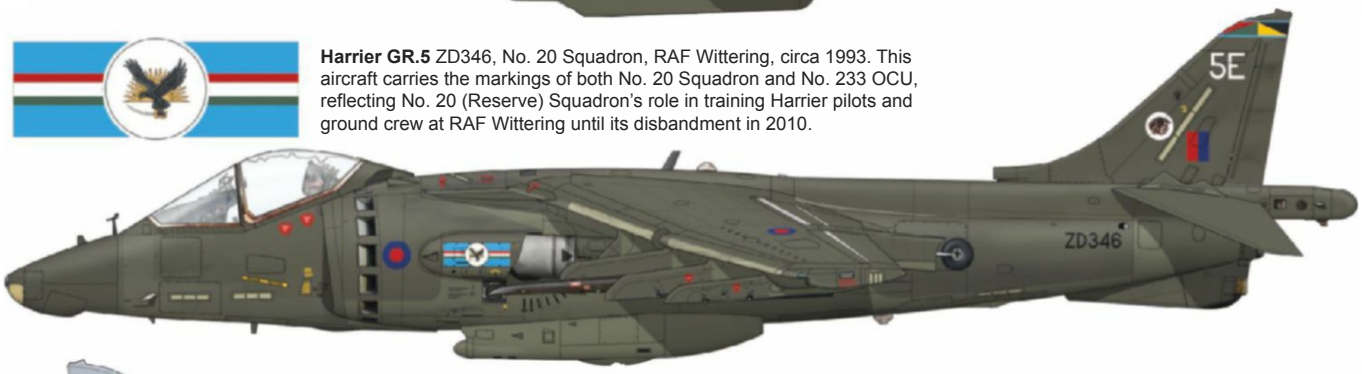
T.12A This variant differed by being equipped with the newer and more powerful Pegasus Mk107 engine of the GR.7A/9A.

The GR.7 was an upgraded GR.5. ***(BAe Systems)***

Harrier GR.7 ZD430, No. 4 Squadron, RAF Gütersloh, August 1991. ZD430 was destroyed following an in-flight fire caused by a bird strike, with the pilot safely ejecting in June 1993.

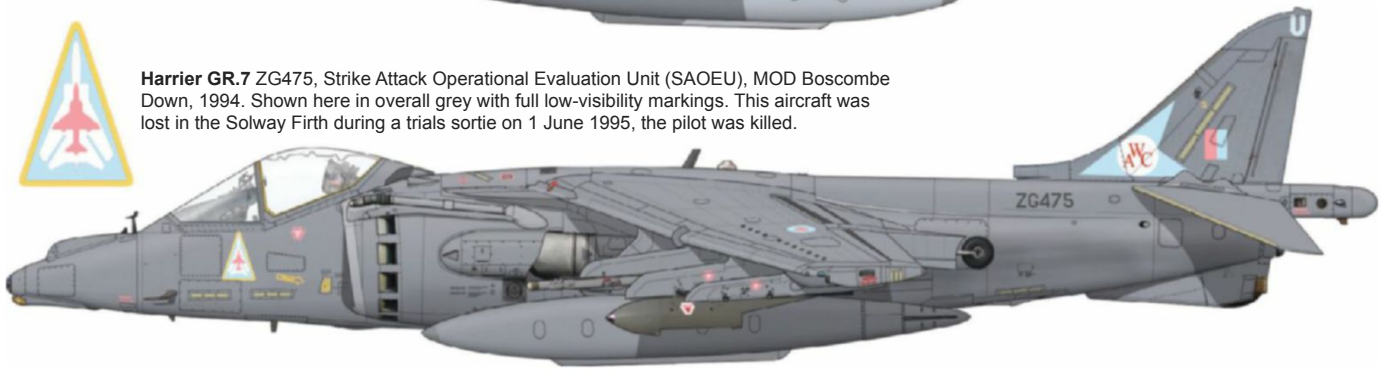
Harrier GR.5 ZD377, No. 233 Operational Conversion Unit, RAF Wittering, June 1992. This aircraft was lost in a crash at RAF Laarbruch in January 1997 due to a jammed flap,with the pilot ejecting safely.

Harrier GR.7 ZG532, No. 4 Squadron, Belize International Airport, September 1993. ZG532, shown here sporting its distinctive tail scheme during a detachment to Belize,and was later lost in an accident in July 1999.



Harrier GR.5 ZD346, No. 20 Squadron, RAF Wittering, circa 1993. This aircraft carries the markings of both No. 20 Squadron and No. 233 OCU, reflecting No. 20 (Reserve) Squadron's role in training Harrier pilots and ground crew at RAF Wittering until its disbandment in 2010.

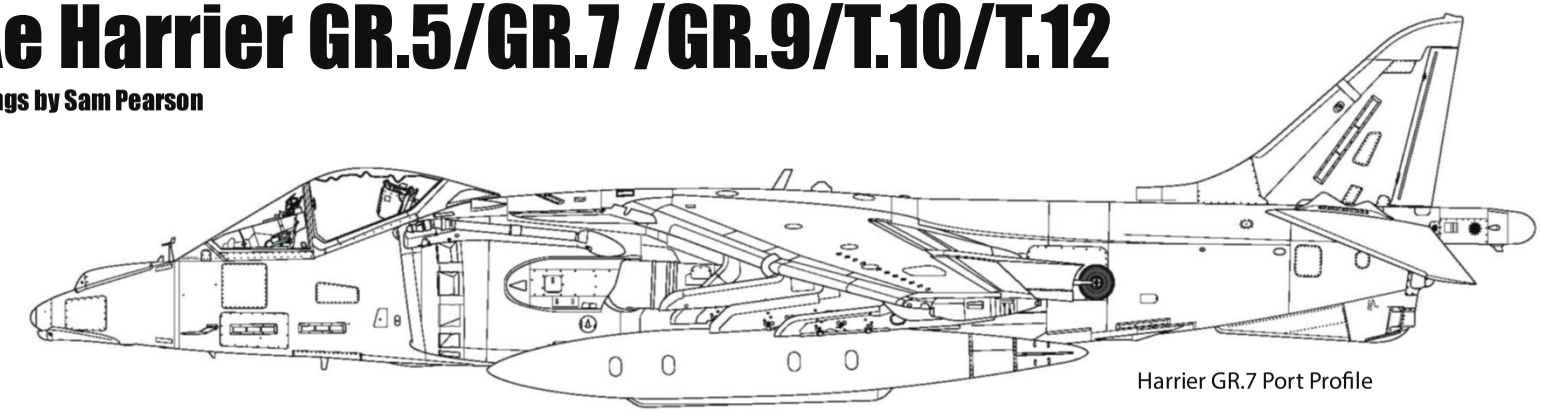
Harrier GR.7 ZG476, No. 4 Squadron, Incirlik Air Base, March 1993. Seen here in overall ARFT Grey with low-visibility national markings, deployed for Operation Warden. ZG476 suffered an engine failure and crashed on finals to RAF Wittering on 19 February 1996, the pilot ejected safely.



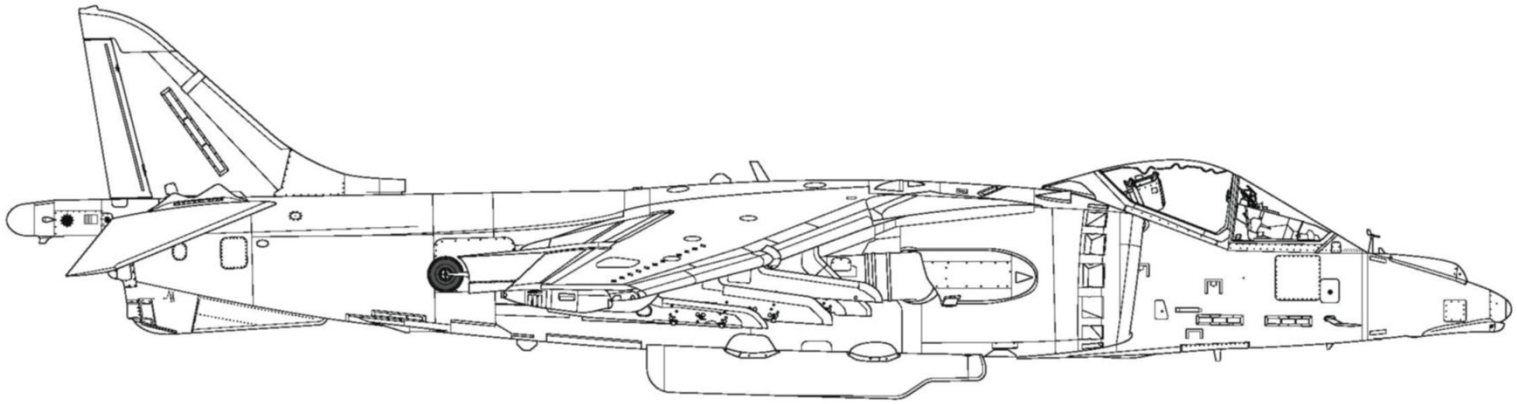
Harrier GR.7 ZG475, Strike Attack Operational Evaluation Unit (SAOEU), MOD Boscombe Down, 1994. Shown here in overall grey with full low-visibility markings. This aircraft was lost in the Solway Firth during a trials sortie on 1 June 1995, the pilot was killed.

BAe Harrier GR.5/GR.7 /GR.9/T.10/T.12

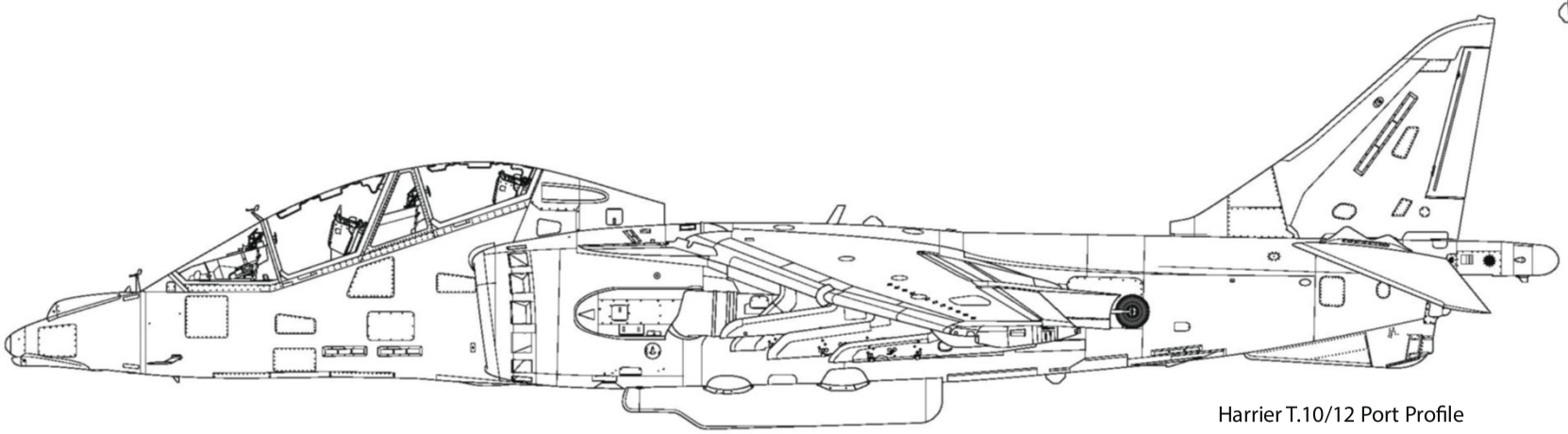
Drawings by Sam Pearson



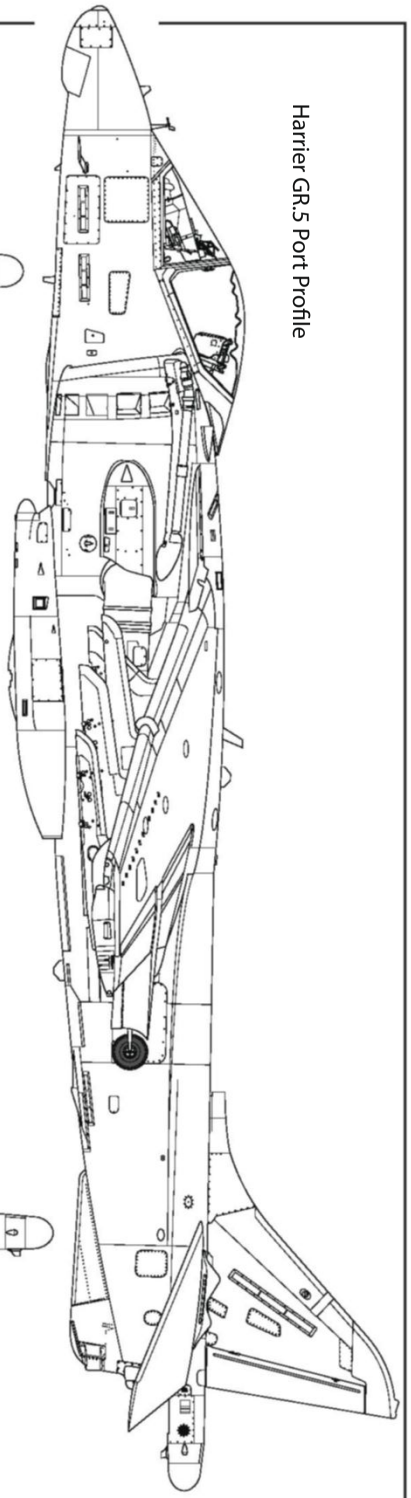
Harrier GR.7 Port Profile



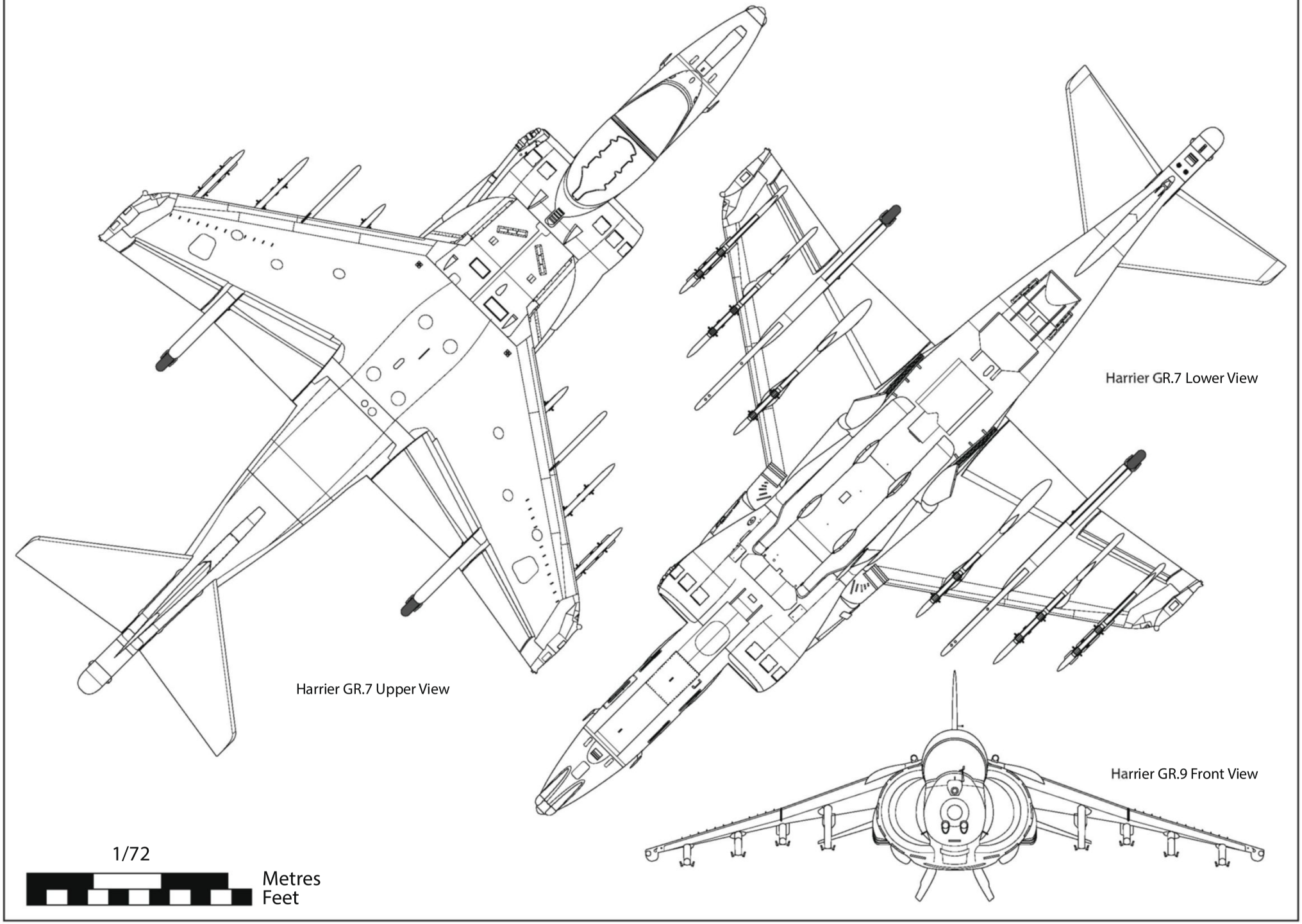
Harrier GR.9 Starboard Profile



Harrier T.10/12 Port Profile



Harrier GR.5 Port Profile


Harrier GR.7 Upper View
Harrier GR.7 Lower View
Harrier GR.9 Front View
1/72
Metres
Feet

Harrier GR.7 ZG478, No. 3 Squadron, RAF Laarbruch, seen at RAF Chivenor, May 1995. Shown here in overall ARFT Grey with low-visibility markings, the aircraft was equipped with a Matra Phimat chaff pod at this time.

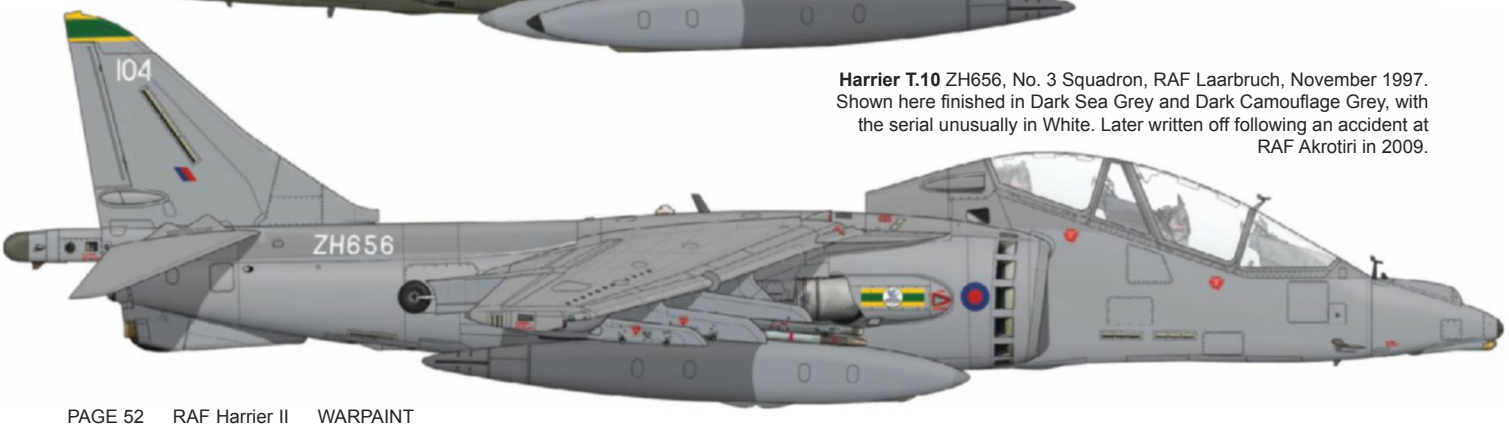
Harrier GR.7 ZG861, No. 3 Squadron, RAF Laarbruch, July 1995. ZG861 was later lost following an engine failure in June 1997; the pilot safely ejected.

Harrier T.10 ZH665, No. 20 Squadron, RAF Wittering, 1996. Early Harrier T-birds were initially finished in the standard NATO Green and Lichen Green scheme. Shown here equipped with Matra SNEB rocket pods.

Harrier T.10 ZH664, No. 4 Squadron, RAF Gütersloh, May 1996. ZH664 went on to participate in the final flypast at RAF Cottesmore on December 15, 2010.

Harrier GR.7 ZG501, Strike Attack Operational Evaluation Unit (SAOEU), MOD Boscombe Down, September 1997. Used to evaluate GR.7 upgrades and refine RAF strike and night-attack tactics.

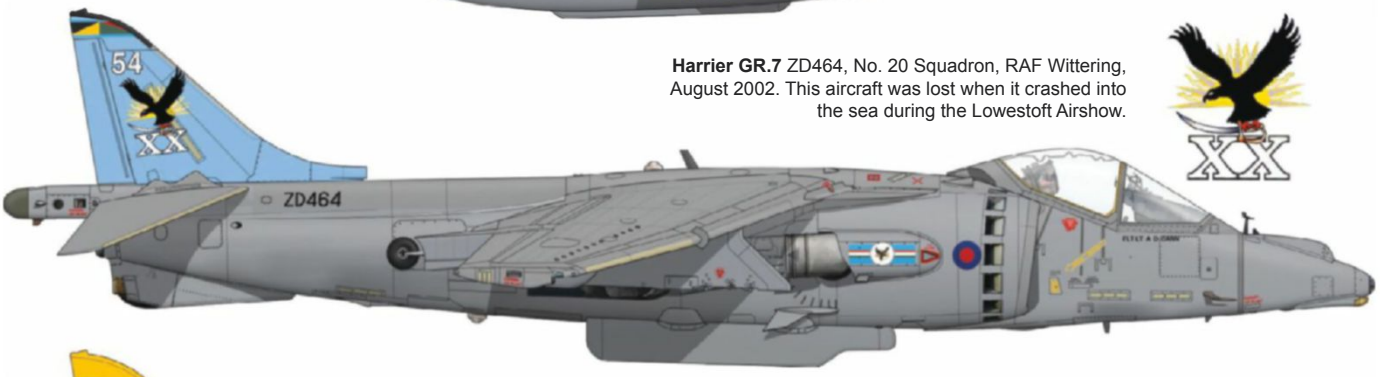
Harrier T.10 ZH656, No. 3 Squadron, RAF Laarbruch, November 1997. Shown here finished in Dark Sea Grey and Dark Camouflage Grey, with the serial unusually in White. Later written off following an accident at RAF Akrotiri in 2009.



Harrier GR.7 ZD328, No. 3 Squadron, RAF Gütersloh, January 1998. By this time, most RAF Harriers had been painted in the Dark Sea Grey and Dark Camouflage Grey tactical scheme. ZD328 carried a NATO Green rudder and refuelling probe.

Harrier GR.7 ZG503, No. 3 Squadron, Gioia del Colle, April 1999. Seen here armed with BL755 cluster bombs and AIM-9L missiles during combat operations over Kosovo in Operation Allied Force.

Harrier GR.7 ZD464, No. 20 Squadron, RAF Wittering, August 2002. This aircraft was lost when it crashed into the sea during the Lowestoft Airshow.



Harrier GR.7 ZD322, No. 3 Squadron, RAF Cottesmore, October 2002. ZD322 carried a special tail marking to celebrate No. 3 Squadron's 90th anniversary.

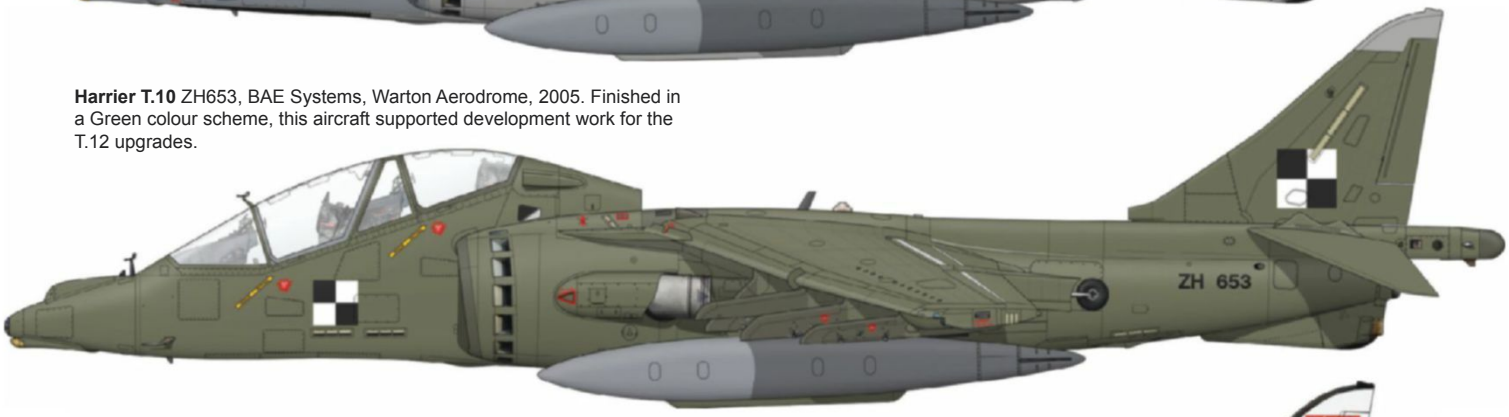
Harrier GR.7 ZG479, No. 4 Squadron, Ahmad al-Jaber Air Base, April 2003. Seen here with shark teeth and eyes, ZG479 was deployed to Kuwait in support of Operation Telic.

Harrier GR.7 ZD408, No. 20 Squadron, RAF Akrotiri, early 2003. ZD408 was another Harrier that featured shark-mouth nose art, shown here armed with Paveway IV LGBs. ZD408 was later lost in a crash near RAF Cottesmore in June 2008; the pilot safely ejected.

Harrier GR.7 ZD379, No. 1 Squadron, RAF Cottesmore, deployed to Bardufoss for exercise Snow Falcon, January 2004. Its standard Dark Sea Grey and Dark Camouflage Grey scheme was overpainted in temporary Arctic white for operations in Norway.

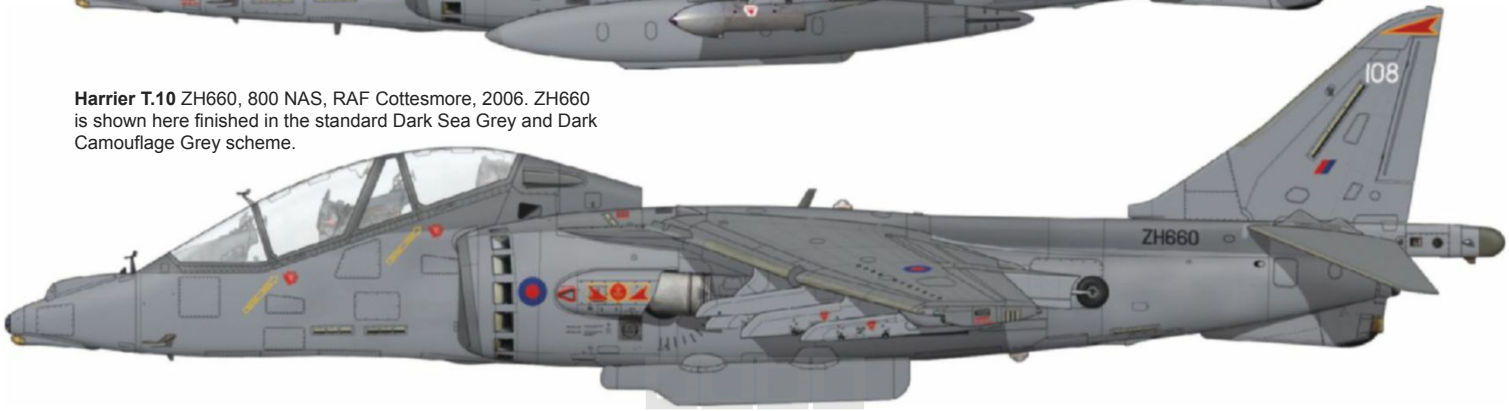
Harrier GR.7 ZG531, No. 1 Squadron, RAF Cottesmore, February 2004. ZG531 is shown here after its return from Norway, with traces of its Arctic scheme still visible following the removal of the temporary paint.

Harrier GR.9 ZD320, BAE Systems, Warton Aerodrome, May 2004. This aircraft served as a trials and development platform for the GR.9 upgrade programme. It carried a colour scheme similar to the Dark Sea Grey and Medium Sea Grey finish applied to the first two production GR.5s.



Harrier T.10 ZH653, BAE Systems, Warton Aerodrome, 2005. Finished in a Green colour scheme, this aircraft supported development work for the T.12 upgrades.

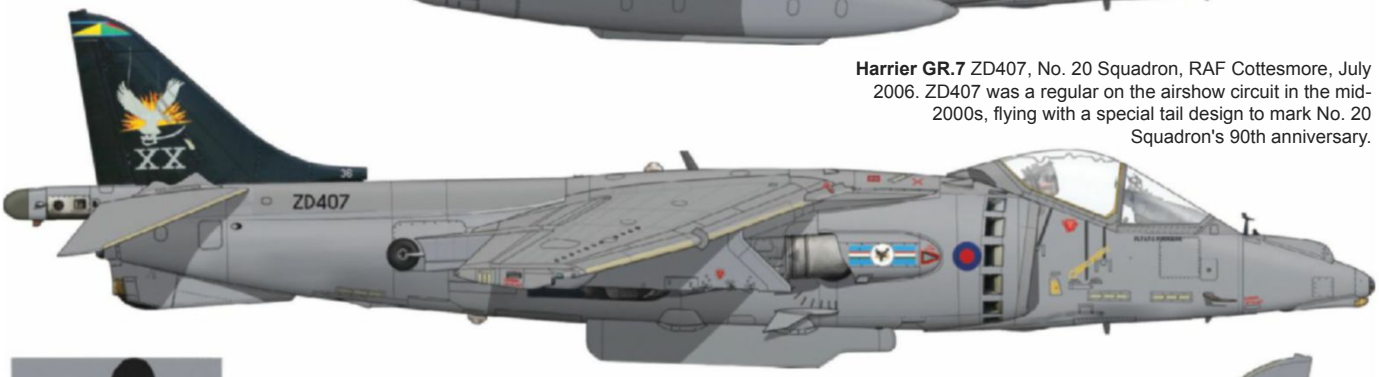
Harrier GR.9 ZG478, No. 41 Squadron, seen at RAF Coltishall, April 2006. ZG478's tail was repainted to celebrate No. 41 Squadron's 90th anniversary.



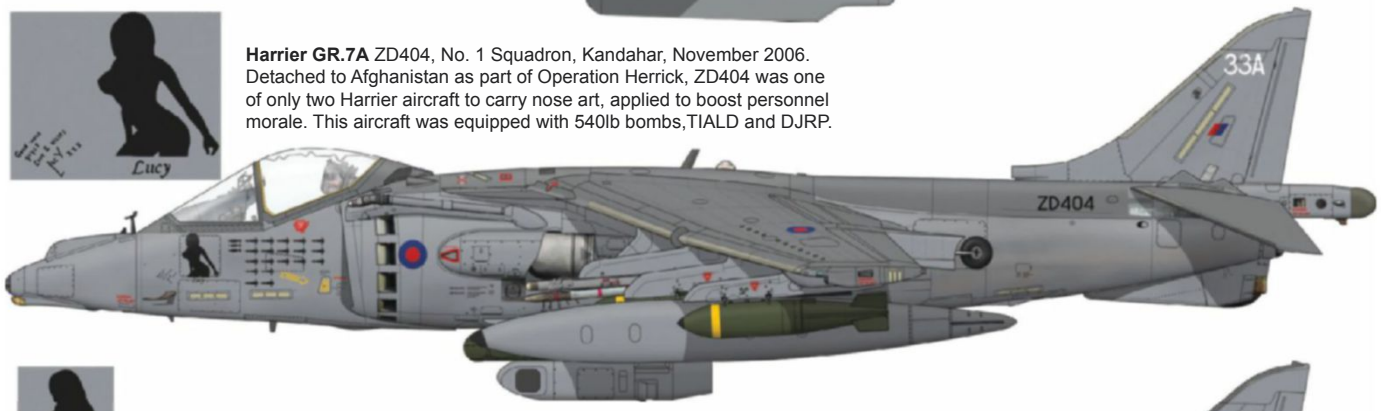
Harrier T.10 ZH660, 800 NAS, RAF Cottesmore, 2006. ZH660 is shown here finished in the standard Dark Sea Grey and Dark Camouflage Grey scheme.

Harrier GR.7A ZG471, No. 4 Squadron, RAF Wittering, May 2006.

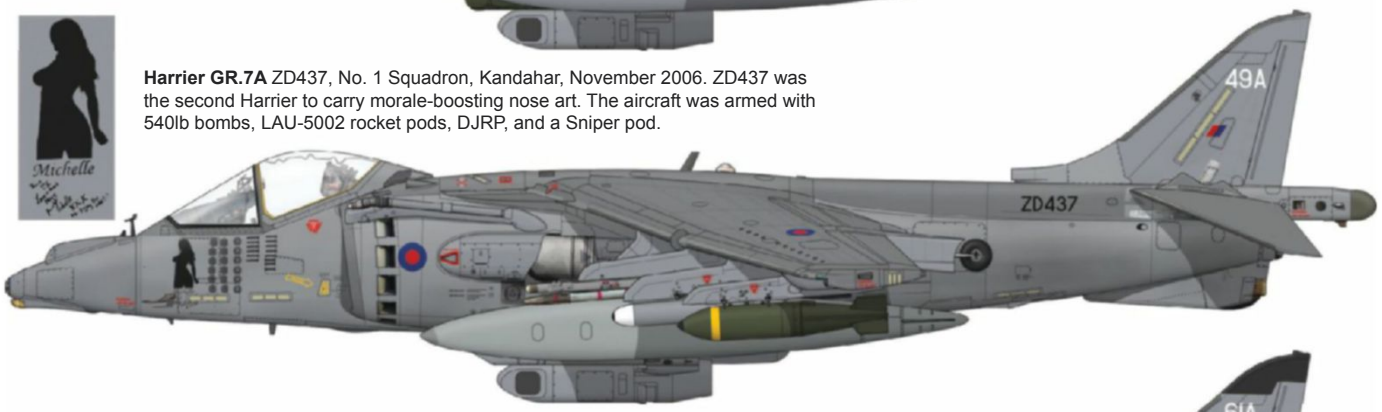
Harrier GR.7 ZD407, No. 20 Squadron, RAF Cottesmore, July 2006. ZD407 was a regular on the airshow circuit in the mid-2000s, flying with a special tail design to mark No. 20 Squadron's 90th anniversary.



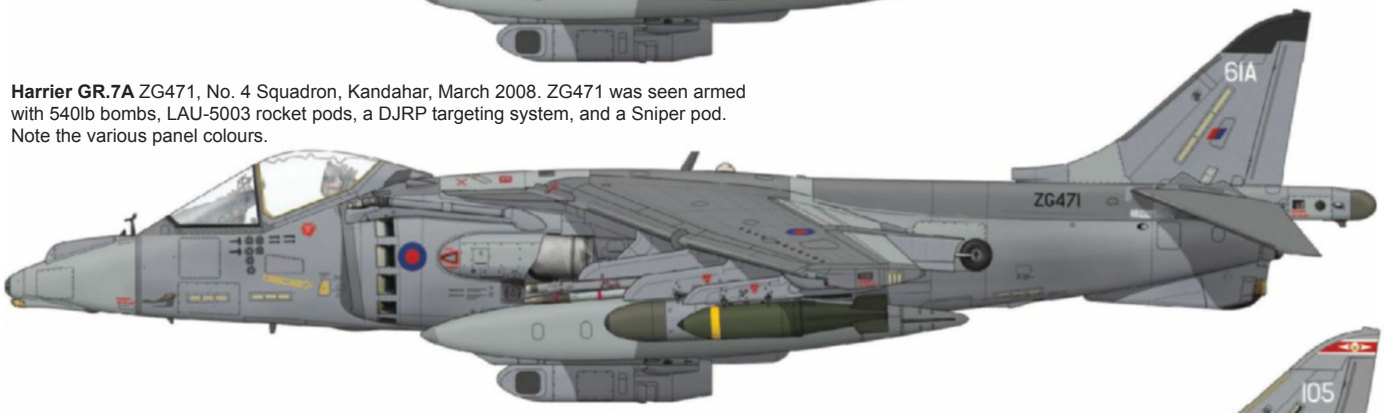
Harrier GR.7A ZD404, No. 1 Squadron, Kandahar, November 2006. Detached to Afghanistan as part of Operation Herrick, ZD404 was one of only two Harrier aircraft to carry nose art, applied to boost personnel morale. This aircraft was equipped with 540lb bombs,TIALD and DJRP.



Harrier GR.7A ZD437, No. 1 Squadron, Kandahar, November 2006. ZD437 was the second Harrier to carry morale-boosting nose art. The aircraft was armed with 540lb bombs, LAU-5002 rocket pods, DJRP, and a Sniper pod.

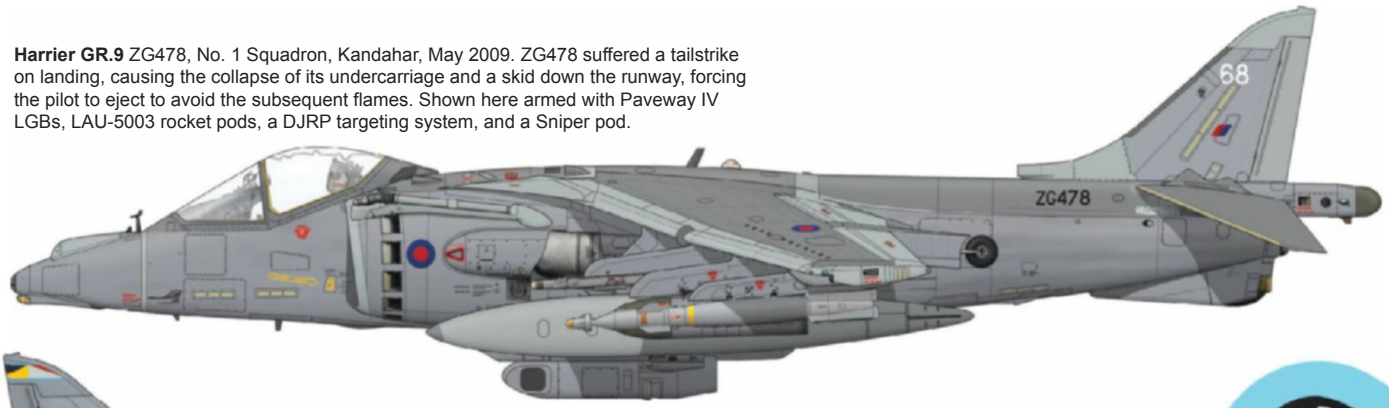


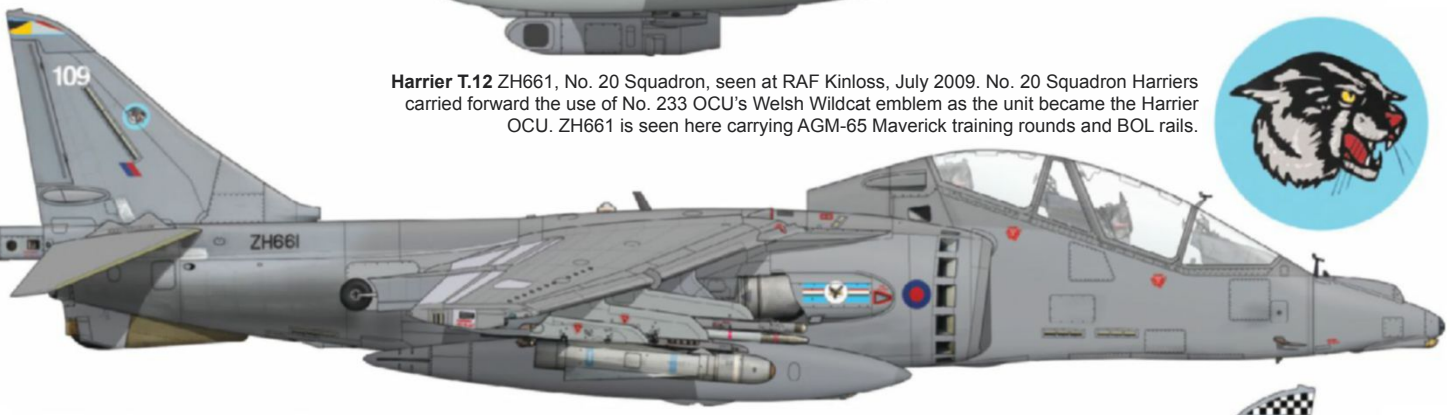
Harrier GR.7A ZG471, No. 4 Squadron, Kandahar, March 2008. ZG471 was seen armed with 540lb bombs, LAU-5003 rocket pods, a DJRP targeting system, and a Sniper pod. Note the various panel colours.



Harrier T.12 ZH657, No. 1 Squadron, RAF Cottesmore, June 2008. ZH657 was finished in the standard Dark Sea Grey and Dark Camouflage Grey scheme.

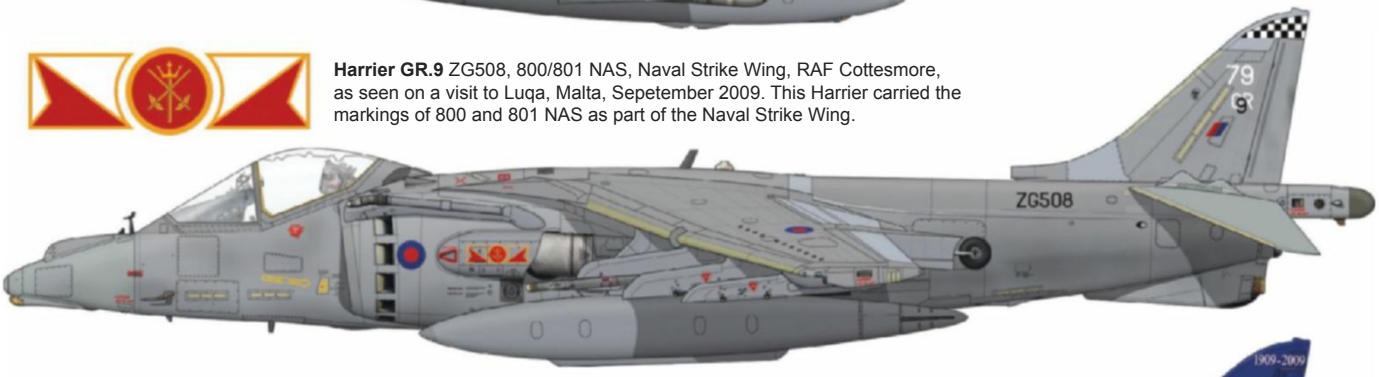
Harrier GR.9 ZG478, No. 1 Squadron, Kandahar, May 2009. ZG478 suffered a tailstrike on landing, causing the collapse of its undercarriage and a skid down the runway, forcing the pilot to eject to avoid the subsequent flames. Shown here armed with Paveway IV LGBs, LAU-5003 rocket pods, a DJRP targeting system, and a Sniper pod.



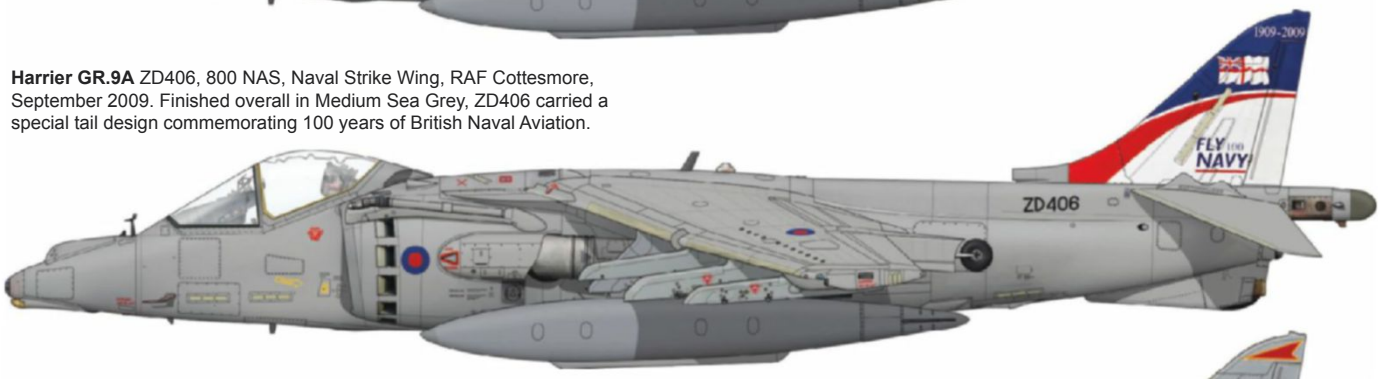


Harrier T.12 ZH661, No. 20 Squadron, seen at RAF Kinloss, July 2009. No. 20 Squadron Harriers carried forward the use of No. 233 OCU's Welsh Wildcat emblem as the unit became the Harrier OCU. ZH661 is seen here carrying AGM-65 Maverick training rounds and BOL rails.

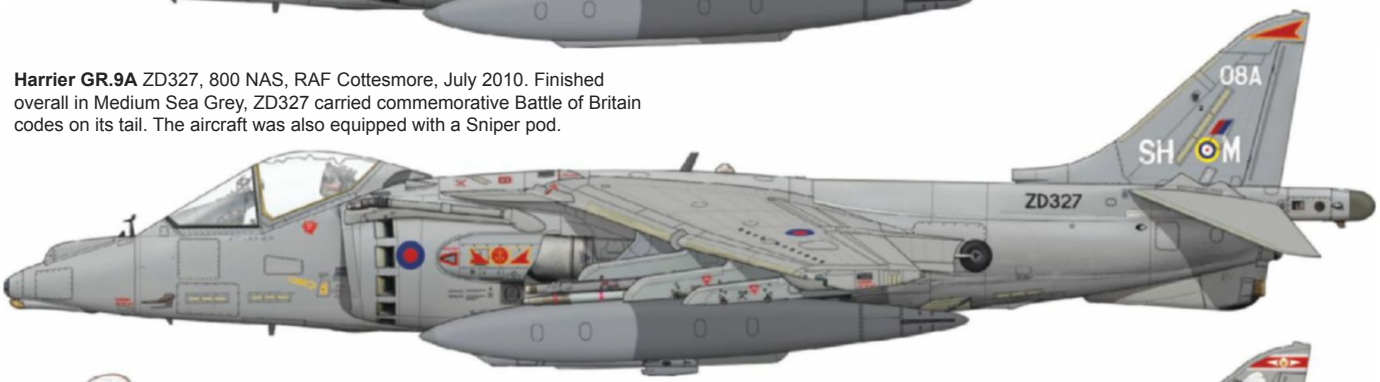
Harrier GR.9 ZG508, 800/801 NAS, Naval Strike Wing, RAF Cottesmore, as seen on a visit to Luqa, Malta, Sepetember 2009. This Harrier carried the markings of 800 and 801 NAS as part of the Naval Strike Wing.



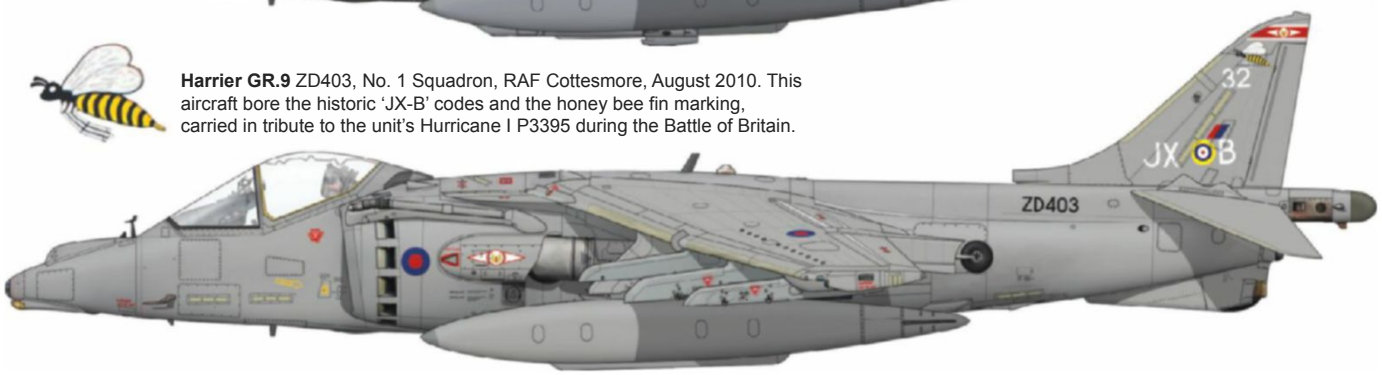
Harrier GR.9A ZD406, 800 NAS, Naval Strike Wing, RAF Cottesmore, September 2009. Finished overall in Medium Sea Grey, ZD406 carried a special tail design commemorating 100 years of British Naval Aviation.

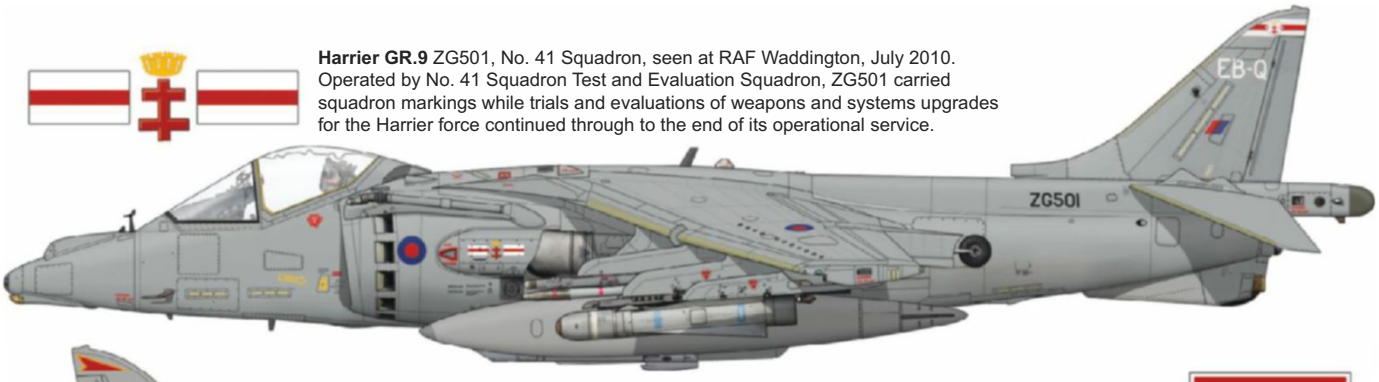


Harrier GR.9A ZD327, 800 NAS, RAF Cottesmore, July 2010. Finished overall in Medium Sea Grey, ZD327 carried commemorative Battle of Britain codes on its tail. The aircraft was also equipped with a Sniper pod.

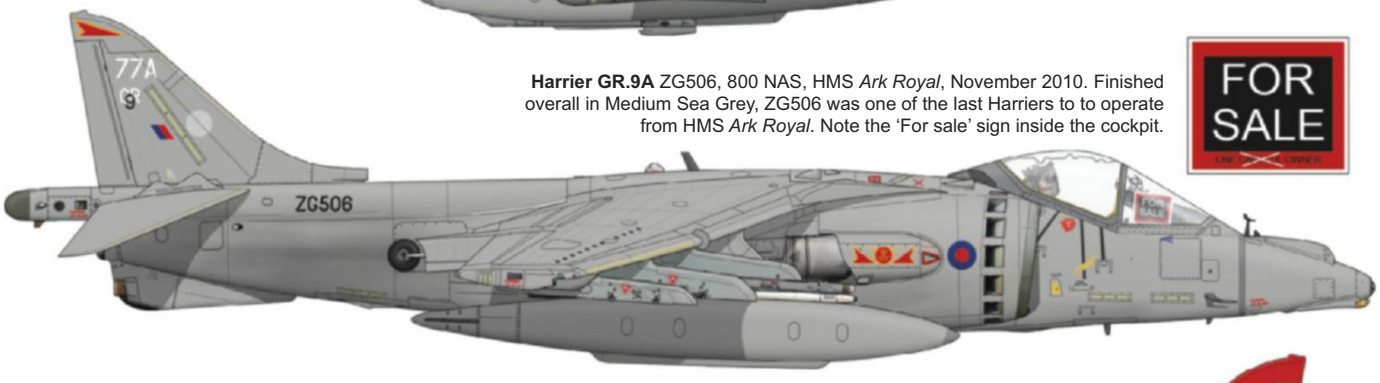


Harrier GR.9 ZD403, No. 1 Squadron, RAF Cottesmore, August 2010. This aircraft bore the historic 'JX-B' codes and the honey bee fin marking, carried in tribute to the unit's Hurricane I P3395 during the Battle of Britain.

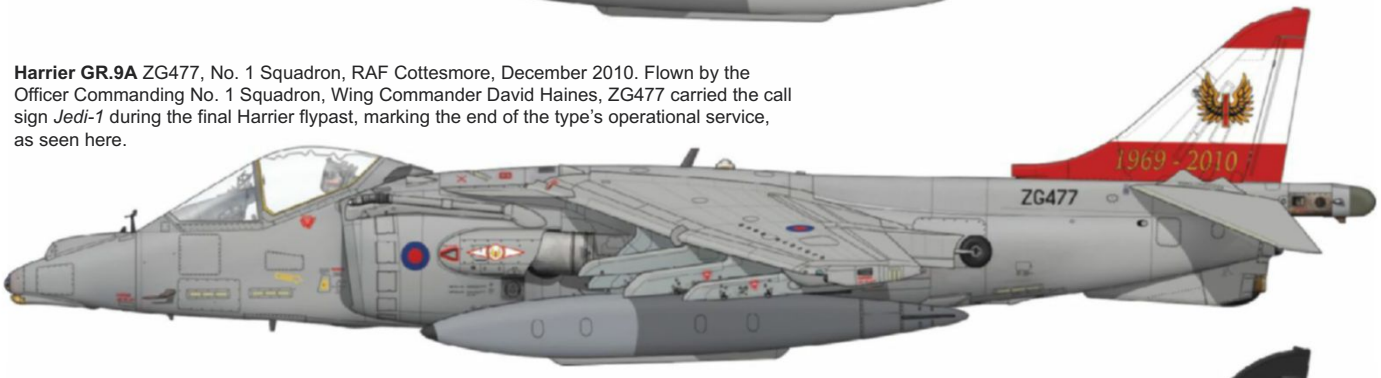




Harrier GR.9 ZG501, No. 41 Squadron, seen at RAF Waddington, July 2010. Operated by No. 41 Squadron Test and Evaluation Squadron, ZG501 carried squadron markings while trials and evaluations of weapons and systems upgrades for the Harrier force continued through to the end of its operational service.



Harrier GR.9A ZG506, 800 NAS, HMS *Ark Royal*, November 2010. Finished overall in Medium Sea Grey, ZG506 was one of the last Harriers to to operate from HMS *Ark Royal*. Note the 'For sale' sign inside the cockpit.



Harrier GR.9A ZG477, No. 1 Squadron, RAF Cottesmore, December 2010. Flown by the Officer Commanding No. 1 Squadron, Wing Commander David Haines, ZG477 carried the call sign *Jedi-1* during the final Harrier flypast, marking the end of the type's operational service, as seen here.

Harrier GR.9 ZG858, No. 4 Squadron, RAF Cottesmore, December 2010. Flown by Wing Commander Simon Jessett, OC of No. 4 Squadron, as *Poison-1* during the Harrier flypast. This aircraft still wore the Dark Sea Grey and Dark Camouflage Grey tactical scheme.

Harrier GR.9A ZD351, 800 NAS, RAF Cottesmore, December 2010. This aircraft was flown by Commander David Lindsay, CO of 800 NAS, as *Cougar-1* during the retirement flypast.

Harrier GR.9A ZG506, No. 1 Squadron, RAF Cottesmore, December 2010. ZG506 was later repainted in this retro scheme and was flown by Joint Harrier Force commander Group Captain Gary Waterfall as *Ninja-1*. It was the last Harrier to land on 15 December 2010.

Above: A No.1(F) Squadron GR.7 comes aboard HMS *Illustrious*. *(RAF)*

Below: A No.20(R) Squadron GR.9 waits its turn on the runway, with IFR probe extended. *(RAF)*

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